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ABSTRACT

This study was initiated to determine the pupil transportation planning and analysis needs of Alberta school systems and, based on these needs, to define an action plan for the development of an information or analytical package that would assist school boards with their pupil transportation activities. Based on the data collected from indepth interviews with pupil transportation supervisors from four school districts, and a brief questionnaire administered to interested delegates at the fall 1978 meeting of the Alberta School Trustees' Association (ASTA) in Edmonton, a more detailed survey form was developed by the study team and distributed by ASTA to all school jurisdictions. The responses from this questionnaire provided the analysis base from which both the perceived and evaluated pupil transportation planning analysis needs were identified. The report is divided into four sections. Section 1 presents the study background and summary. Section 2 outlines the survey results and summarizes the planning and analysis needs identified. Three areas identified where immediate development work is required were a data storage and retrieval system, a pupil forecasting model, and a computerized vehicle routing model. A systematic stepwise approach for pupil transportation management is presented in section 3, and the work program to develop the planning and analysis is outlined in section 4. (Author/MLF)

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Planning and Analysis Needs for Pupil Transportation

by

Stanley Associates
Edmonton, Alberta

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PLANNING AND ANALYSIS NEEDS FOR PUPIL TRANSPORTATION

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SECTION 1

INTRODUCTION AND SUMMARY

1.1 BACKGROUND

Pupil transportation plays an important role in the successful delivery of the total educational program in the province of Alberta. The availability of a pupil conveyance system has contributed to the improvement of the quality and efficiency of schools, particularly in rural areas where it has permitted the construction of larger schools with better facilities and programs. In addition it has helped provide access to educational opportunities for children in the more remote areas of the province.

Of course, the value of the transportation service provided depends heavily on its quality and efficiency since an unreliable and uneconomical pupil transportation service is nothing more than a burden and an inconvenience to a school board.

The annual costs of providing pupil transportation in Alberta are currently in the order of 30 to 35 million dollars. This sum represents approximately five percent (5%) of the total educational expenditures in the province. Of the 30 to 35 million dollars, over 80 percent (80%) is expended by rural school systems. For these systems transportation costs typically represent 10 to 11 percent of their educational operating fund budgets.

The need to insure that maximum efficiency is obtained by provincial pupil transportation systems when spending these large sums of money, has been identified in several past studies commissioned on this topic. In

particular Bardock and Matthews[1] stated:

> "The present period of major reconsideration brought about by financial constraints is a critical time in the history of pupil transportation in Alberta. In this time, when major readjustments are being considered and/or made, there exists enough background of experience with school transportation that inefficient practices can be eliminated."

The report also added:

> "... it became evident that school boards have to give more consideration to including policy development, measurement and control of performance, and overall planning as essential ingredients in the management of their pupil conveyance system."

In general, following publication of the above noted report, efforts have been made by school boards in the province to improve their pupil transportation planning and operations activities. Unfortunately, in many instances, particularly in the rural areas, these improvement efforts have been constrained by the availability of data and resources which would permit the school boards to conduct the analyses required to attempt to optimize their transportation delivery systems.

In recognition of this need the Alberta School Trustees Association (ASTA) initiated a study (funded by Alberta Education) to determine the pupil transportation planning and analysis needs of Alberta school systems and based on these needs to define an action plan for the development of an information or analytical package which would assist

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(1) Bardock, E.F. and Mathews, L.W., Pupil Transportation, Alberta Education, Edmonton 1973

school boards with their pupil transportation activities.

Stanley Associates was commissioned by ASTA to undertake this investigation in the summer of 1978. This report summarizes the results of the study.

1.2 STUDY OBJECTIVES

In undertaking this investigation, broad study objectives were developed by ASTA and Alberta Education with input from Stanley Associates. Briefly these objectives can be summarized as follows:

1. To identify areas of potential deficiencies in the process which is currently being used to plan and operate pupil transportation systems.

2. To evaluate these needs and identify information or analytical techniques which would assist in alleviating these deficiencies.

These objectives were formulated in the hope that the ameliorated techniques identified would lead to better planning, better policy formulation, more timely implementation and consequently to an improved pupil transportation service in the province.

1.3 STUDY METHODOLOGY

At the study outset in-depth interviews were held with pupil transportation supervisors from the school districts of Sturgeon, Strathcona, Rockiview and Lethbridge to obtain first-hand knowledge about the principal issues facing pupil transportation systems in Alberta.

These initial contacts were followed by the distribution of a brief questionnaire to interested delegates at the fall 1978 ASTA conference in Edmonton.

Based on the data collected from these sources a more detailed survey form was developed by the study team and distributed by ASTA to all school jurisdictions. The responses from this questionnaire provided the analysis base from which both the perceived and evaluated pupil transportation planning analysis needs were identified.

In conjunction with the above a selected literature search was conducted of published material dealing with pupil transportation management and with suppliers of specialized equipment and software programs dealing specifically with pupil transportation.

Following the assembly of all relevant study data a systematic step wise process was identified for use in the design and planning of pupil transportation services. Based on this approach, information and analytical needs were identified and a work program was defined to develop the required information and analytical methodology packages.

1.4 REPORT FORMAT

This report is divided into four sections. Section 1 presents the study background and summary. Section 2 outlines the survey results and summarizes the planning and analysis needs identified. A systematic step wise approach for pupil transportation management is presented in Section 3. Finally the work program to develop the planning and analysis package is outlined in Section 4.

1.5 SUMMARY

A summary of the principal study findings, conclusions and recommendations is presented below. For more detailed information specific reference should be made to the appropriate report section.

1. A majority (about 75%) of the respondents to the survey were largely rural school boards with low population densities. These boards expressed several consistent concerns and appear to be having problems meeting the current guidelines for the Alberta Education Grant Assistance Program.

2. Based on the evaluations summarized in the report the following policy, planning and operating needs were identified:

   - To establish policy guidelines for the provision of pupil transportation services and to establish well defined roles, duties and responsibilities for the administration of pupil transportation.

   - To include a more detailed transportation impact evaluation when the location of a new school is being finalized.

   - To establish service criteria to be used by all school boards for planning, monitoring and evaluating pupil transportation service.

   - To establish a consistent systematic approach for planning school bus routes.

- To develop the methodology for quickly and accurately evaluating the impacts of alternative routing concepts on transportation costs, the level of service provided, etc.

- To provide school boards with data which will assist them in the proper planning of pupil transportation budgets for periods of up to five years.

- To provide periodic seminars where information concerning pupil transportation matters can be discussed.

- To ensure that all drivers, whether board based or contractor hired participate in appropriate training programs.

- To ensure that school boards accept the principle that marginal changes to school operations should be made where the trade-off involves substantial improvements to the efficiency of pupil transportation systems.

- To establish procedures and criteria for the monitoring and evaluation of existing pupil transportation services.

3. Resolution of the above needs would in most instances be accomplished by dissemination of transportation information to all school boards in the province and by the rigorous application of existing and suggested pupil transportation management techniques.

4. Three areas were identified where immediate development work is required to assist with the improvement of pupil transportation system planning and operation. These include:

- The development of a data storage and retrieval system.
- The development of a pupil forecasting model.
- The development of a computerized vehicle routing model.

5. Although not specifically outlined in the report, it is suggested that a Pupil Transportation Manual be prepared as a means of disseminating information to school boards. This manual would contain planning and route design techniques as well as other relevant information such as; copies of the Highway Traffic Act, typical board policies, sample forms to be used for conducting surveys, system evaluation criteria, etc.

SECTION 2

PLANNING AND ANALYSIS NEEDS FOR PUPIL TRANSPORTATION

2.1 GENERAL

This section of the report summarizes the results of both the questionnaire distributed at the ASTA convention and the more detailed survey form distributed to all Alberta school districts. Based on the results of these surveys current pupil transportation management practice, and both perceived and evaluated needs were identified.

2.2 ASTA CONFERENCE QUESTIONNAIRE - RESULTS

For the most part the results of this brief questionnaire (see Appendix A) were similar to those obtained from the more detailed survey form. Accordingly no summary is provided here. For information purposes a complete tabulation of the results is contained in Appendix A.

2.3 SURVEY RESULTS

In early December 1978, survey forms were distributed to each of the approximately 120 school jurisdictions in Alberta which provide some form of transportation service. By the end of January, 1979, 53 survey forms (44%) had been returned and were used for the tabulations. Of the 53 survey forms returned seven were from urban areas, and 38 were from rural areas. The remaining eight were from semi urban school jurisdictions located on the fringes of urban areas. A complete copy of the distributed survey form along with a detailed tabulation of the results can be found in Appendix B. For simplicity and organizational purposes

the survey form was divided into three sections; Organization, Planning and Operations. Accordingly, the survey results are discussed under each of these headings. For clarity an annotated version of the question(s) asked precedes each section, along with the number of valid responses received for that particular question.

2.3.1 Organization

How many people are involved with pupil transportation and what are their duties and responsibilities (53 responses).

Forty two percent (22) of the respondents had no transportation department per se, 28% (15) had from 1 to 4 people responsible in a department while the remaining 30% (16) of the respondents indicated that groups of five or more (including committees, trustees or the school board itself) were responsible for the transportation of students to and from school.

Thirty respondents provided job descriptions as part of their answers. Of these, 10% (3) indicated that there was a person responsible exclusively for the operations aspects of pupil transportaion, 7% (2) indicated that they employed a person exclusively to plan for pupil transportation, while 27% (8) replied that they employed a person(s) exclusively to plan for and monitor the operational facets of pupil transportation.

The principal title of the individuals responsible for pupil transportation were listed as follows:

- Secretary Treasurer -	41% (16)
- Transportation Supervisor-	23% (9)
- Trustee -	13% (5)
- Superintendent of Schools-	8% (3)
- Other -	15% (6)
	100% (39)

2.3.2 Planning

When is pupil transportation considered? (53 responses)

Only 57% (30) of the respondents gave consideration to pupil transportation when selecting a school location. Of these 30 this consideration was given at the following times:

- 66% before
- 16% during
- 18% after

the establishment of the school location. However, from the more detailed responses it is doubtful whether in any jurisdiction alternative bus routing schemes were actually developed for each of the school locations under consideration.

What criteria are used to plan bus routes? (42 responses)

When planning bus routes many factors must be considered. The following criteria were the most widely used by the respondents to this question:

- Number of pubils per route	60% (25)
- Maximum travel time	60% (25)
- Maximum travel distance	50% (21)
- Maximum walking distance to pick-up point	64% (27)
- Maximum no. of stops per mile (kilometer)	21% (9)
- Maximum no. of reloads/transfers	29% (12)
- Location of railway crossings	33% (14)
- Operating Costs	31% (13)
- Avoidance of double tracking or cross tracking	48% (20)
- Traffic volumes	19% (8)

In general the above were not established by board policy but rather were guidelines used by the route planner.

What sources of information are used for route planning purposes? (44 valid responses)

The respondents to this question stated, not unexpectedly that the item which was the most useful in the route planning process was a county or city road map - 93% (41). The other sources of information which 40% or more of the school districts considered to be very useful are as follows:

- School location maps - 61% (27)
- School catchment area map - 61% (27)
- Names and addresses of students - 66% (29)
- Daily opening and closing time - 52% (23)
- Grade levels of students - 43% (19)

It was also interesting to note that almost 50% of the respondents based their route planning almost solely on achieving the 85% bus load factor required for provincial funding assistance.

The least useful items of information were reported as:

- Police accident reports
- Traffic volumes
- School class schedules

What methodology is used in planning and designing bus routes?
(40 valid responses)

A majority (40%) of the school districts followed a methodology similar to that briefly outlined below:

- Review existing bus routes and requests for changes
- Obtain a list of school beginners and transfers with names and addresses
- Draft up new bus routes as required
- Assign buses to new routes (ensuring that 85% load factor is reached)
- Attempt to reduce unnecessary costs

The second most popular method (18%) used is more systematic and applies to both new and revised routing plans. It can be summarized as follows:

- Students' names and addresses are placed on a large scale map
- The drop-off and pick-up times are calculated as well as the daily miles to be travelled
- Overlays are used on which the bus routes are drawn
- Revisions and updates are made to restrict double tracking, cross tracking etc.

The remaining methodologies reported (43%) cannot be classified into any particular category. A cross section of some typical responses are:

- Secretary-treasurer consults a transit system operator (usually in an urban area)

- Bus driver follows a tentative route where he contacts parents and establishes an expected load factor
- Bus drivers gather together in a room and discuss their individual routes from the previous year and make changes where necessary

What information if available would be most useful in planning and designing bus routes?

The following items were considered to be the most useful for bus route planning purposes:

	favourable responses / total responses
- population projection figures for both students and residents	30 / 39
- fleet size projections	22 / 31
- financial data projections	23 / 30
- the capability to evaluate quickly and accurately the impacts of alternative bus routing plans on both costs and level of service provided	25 / 42

Although not available to any of the school systems at the present time, computerized school bus routing models were considered to be not very practical by 70% of the respondents.

From the responses given by the school district representatives it may be stated that they consider both of the following sources of information to be only marginally useful:

- short and long range projections for facilities
- monthly updates of name, address, and grade level of each pupil requiring transportation.

Do you currently have long range plans? (40 valid responses)

The responses to this question break down as follows:

		1 Year		5 Year
-	Pupil transportation	54%	-	27%
-	Pupil enrollment	28%	-	54%
-	Bus fleet characteristics	50%	-	35%
-	Facility requirements	25%	-	48%
-	Financing methods	47%	-	36%

2.3.3 Operations

Would seminars be useful? (41 valid responses)

An overwhelming number of respondents (76%) favoured these seminars for exchanging ideas on pupil transportation. It should be noted here that, at present some seminars pertaining to pupil transportation are already being undertaken, namely those sponsored under the auspices of the Alberta School Contractors and Alberta Transport Safety. The responses to this question, however, indicate that the content should perhaps be altered to include more instructional and educational material on pupil transportation planning management and operations.

What about a bus driver training program? (45 valid responses)

Of the total respondents 76% (34) indicated that no such program exists. Of these about 65% contracted out at least 50% of their bus operations.

Twenty-four percent (11) of the jurisdictions had a driver training program. Usually this was administered by the school board (5) or by a private firm (3).

Are you prepared to modify school operations to assist pupil transportation? (40 valid responses)

A majority of the respondents (73%) stated that they were prepared to modify school operations in order to facilitate a more efficient pupil transportation system. Of these 29 school districts, 20 indicated that flexible school hours had been used, 2 indicated other modifications and 7 did not specify what course had been taken.

Eleven districts indicated opposition to the modifications of school operations to assist pupil transportation. The reasons for this opposition can be categorized as follows:

- present system is satisfactory (7)
- transportation of pupils should be geared to the school system (2)
- modifications of the school system had not been considered yet (2)

What is your ratio of board owned to contracted buses? (45 valid responses)

The responses received to this question are broken down as follows:

% Board Ownership	No. of Responses
0	19
1 - 25	4
26 - 50	4
51 - 75	1
76 - 99	6
100	11
	45 districts

Three of the responding districts had a policy with regard to bus ownership. Two of the policies dictated that 100% of the buses should be contracted, while the remaining district's policy required 100% board ownership of the school buses. It should be noted that province wide board ownership accounts for approximately 50 percent of the school bus fleet.

Use of school buses for extra-curricular activities (44 valid responses)

Of the responses received 100% used their fleets for extra-curricular activities. Of these 32 were governed by board policy while the remainder were left up to individual circumstances. The average approximate numbers of bus trips made for extra-curricular activities by each school district are:

- 150 per year
- 16 per month
- 4 per week

How important is the Alberta Education pupil transportation grant program? (41 valid responses)

Factor	Not Important	Moderately Important	Very Important	Total
- Planning school bus routes	7	10	24	41
- Establishing fleet size and characteristics	5	5	29	39
- Purchasing new buses	12	7	21	40
- Total number of pupils to be bussed	14	8	19	41
- Pupil in bus travel time	15	15	11	41
- Establishing school attendance boundaries	16	13	12	41

Central agency purchase of school buses (40 valid responses)

Of the responding districts, 43% (17) felt that there would be a benefit derived from the establishment of a central agency to buy buses while 57% (23) did not feel any benefit would be gained.

Impact of early childhood program service. (42 valid responses)

Twenty-nine percent (12) of the school districts stated that early childhood service has a significant impact on the planning and financing of the operating budget for pupil transportation. This concern was not shared by a majority of the respondents since 19% (8) felt that little impact results and 52% (22) felt that no impact results.

Problems experienced with pupil transportation. (28 valid responses)

As can be appreciated the problems were many and varied, however for analysis purposes they can be categorized into six classifications as follows:

- Operations and Maintenance - 75% (21)
- Planning - 57% (16)
- Policy - 43% (12)
- Drivers - 39% (11)
- Students - 18% (5)
- Other - 14% (4)

Other problems listed included:

- Increasing public demand for better service
- Bus manufacturers should review capacity of buses
- Bus size is too small
- Pupils improperly dressed

Complaints with respect to pupil transportation. (36 valid responses)

Ten of the most frequent complaints are listed below in order of frequency:

		# of responses
1.	Discipline on buses	17
2.	Length of travel time on buses	15
3.	Closer gate service	9
4.	Drivers too early for pick-up and late for drop offs	8
5.	Overcrowding	7
6.	Buses late for pick-ups	4
7.	Drivers speed	4
8.	Buses inadequate/buses too cold	4
9.	Not enough extra-curricular travel provided/ contractors complain about low pay	4
10.	Parent-driver conflicts	3
		75 (84% of responses)

The total number of responses can be categorized into the following classifications: (the total is greater than 36 since each response could include more than one category)

		# of responses
1.	Policy	20
2.	Student Discipline	18
3.	Travel Time	15
4.	Adherence to Schedule	11
5.	Driver oriented	9
6.	Adequacy of Buses	8
7.	Other	8
		89

"Other" complaints include: driver/parent conflicts, traffic, safety, bus repairs take too long, routing.

2.4 EVALUATION OF SURVEY RESULTS

This section presents an evaluation of the survey results which were used to determine the deficiencies in the current operation and identify the planning and analysis needs. As in Section 2.3 the results are evaluated under three headings; organization, planning and operations.

In general it can be stated that a majority (about 75%) of the respondents were largely rural school boards with lower population densities. This was not entirely unexpected since with these boards pupil transportation costs account for upwards of 10% of their entire operational educational budgets, and consequently pupil transportation is a major concern. Interestingly, it also appears that the boards who responded expressed concerns about

the current Alberta Education Grant Assistance Program. This would appear to indicate that the rural school boards in general are having difficulty meeting the requirements for the Grant Assistance Program.

2.4.1 Organization

Responses indicate that only about 25% of the school districts have a department of one form or another which exclusively looks after matters pertaining to pupil transportation. This is somewhat surprising, since with the majority of the respondents being rural boards significant (10% or more) amounts of their total operational educational budgets are expended on this activity.

In the remaining jurisdictions, often the individual(s) responsible for transportation had primary duties and responsibilities which were completely unrelated to transportation. Given the demands which would likely be made on the individual from his/her principal role, it is not difficult to see that little time would usually be left over for transportation. This observation is supported in part by the job descriptions attached to the survey forms. In general these were not well defined and they indicated widespread responsibilities ranging from insuring that the buses were cleaned properly to distributing report cards.

It can be concluded from the responses that a need exists to establish policies for the provision of a transportation service organization and to establish well defined roles, duties and responsibilities for individuals responsible for pupil transportation. In particular, policy issues should be separate and distinct from the planning and operations functions since policy issues would necessarily be dealt with by the school board whereas planning and operations functions could and should be handled by the administration.

This does not necessarily imply that each school board must hire a transportation supervisor. This can be decided at a later date. What is important is that the board establish the duties and responsibilities of a pupil transportation administration. Following this, the work load required for this activity for the particular school jurisdiction can be evaluated, and a decision can be made as to whether a full-time transportation supervisor is warranted.

2.4.2 Planning

A number of jurisdictions expressed the opinion that school location is unaffected by pupil transportation considerations. All of these were primarily urban or urban fringe areas which have higher population densities than most rural areas. A majority of jurisdictions did indicate that pupil transportation considerations have a direct bearing on school location, however the method by which this consideration is given is suspect since none of the respondents indicated that alternative transportation servicing concepts were evaluated as part of the overall school location process.

It is recognized that transportation is not the only or even perhaps the principal consideration which impacts school location, however, a need exists to include a more detailed transportation evaluation when the location of a new school is being finalized.

When planning bus routes a number of factors must be considered. In particular service criteria must be established so that the route planner has a measure upon which to base his design, monitor performance and establish the actual cost of providing a given level of transportation service. The responses received indicate a lack of adequate guidelines in most of the jurisdictions, to permit an evaluation of the resulting bus routes.

This indicates that a need exists for all school boards to establish guidelines to be used for planning, monitoring and evaluating pupil transportation service. Of course these guidelines will vary for each jurisdiction depending on population densities and available roadways. This is supported in part by the fact that the six jurisdictions reporting average daily pupil on-bus travel times equal to or greater than 90 minutes also reported problems in Question 17 with respect to sparsity of population and ridership.

Proper planning is essential to ensure that efficiencies are maintained in the transportation system. In particular planning insures that no significant unexpected expenditures will be encountered. In general unexpected expenditures decrease the efficiency of a transportation service since the unplanned costs have to be incorporated into a budget at a premium.

The responses outlined a variety of methodologies for planning bus routes, however with few exceptions these appeared to provide only a cursory look at the expected demand. From this it may be concluded that a need exists for the establishment of a consistent, systematic approach for planning bus routes.

An interesting observation with respect to planning, is that a significant majority of the respondents indicated that computerized school bus routing models would not be useful as an aid for planning pupil transportation services. On the other hand, an equal majority of respondents expressed a desire for a capability to evaluate quickly and accurately the impacts of alternative bus routing schemes on budgets and level of service provided. This is somewhat contradictory since a computerized routing model would certainly assist in evaluating alternatives even if the routes developed are subsequently improved and revised manually.

The principal conclusion which is drawn from an analysis of the planning related responses is that a need exists to provide school boards with data which will assist them to plan properly for their pupil transportation budgets for periods of up to five years. This need was overwhelmingly expressed in one form or another in each of the questions asked in this section.

2.4.3 Operations

A need was expressed by a majority of the respondents for periodic seminars where information pertaining to pupil transportation matters could be discussed. Again remembering the rural nature of the school boards responding it can be seen that some school boards in the province simply do not have the resources to insure that they are up to date on all new developments pertaining to pupil transportation management.

The need expressed for a driver training program was perhaps not as great as originally anticipated. However, examination of the responses indicated that of the jurisdictions which currently do not have a training program, 65% contract most of their school busing. Interestingly, one of the more common complaints received by these jurisdiction pertained to drivers. Based on this information it may be concluded that a need exists for each jurisdiction to ensure that all of their drivers, both contracted and board hired should participate in a training program which includes safe driving and operation of vehicles as well as handling the pupils on the vehicles.

In general, educational content determines the school operating schedule. This leaves little flexibility for altering the schedule for other considerations such as transportation. However, a majority of the respondents appear to appreciate that some flexibility in school operations

does exist especially to accommodate situations where a substantial improvement can be made to the transportation system. For example, school and grade capacities can be changed marginally through alterations and use of portables. Also, bell times may be altered slightly and if necessary school attendance area boundaries can also be changed. Implementation of any of these changes could improve the efficiency of a pupil transportation system.

The Alberta Education Pupil Transportation Grant Assistance Program was established, in part, to ensure control over efficient use of grant funds. For this reason one of the conditions for full assistance is that the load factor on the vehicles used for transporting pupils must be at least 85%. As can be expected this requirement has a significant impact on how transportation systems are planned and operated. The responses received indicate that this impact is most pronounced in the following areas; planning school bus routes, purchasing new vehicles, the number of pupils on each vehicle and establishing the number and size of the vehicle fleet.

Interestingly, when comparing these results with those of questions 17 and 18, (problems encountered with pupil transportation and complaints) the most frequent problems and complaints received are related to the above four areas. This implies in part that some of the school jurisdictions which responded are currently experiencing difficulties in satisfying the requirements of the grant structure. Some but not all of these difficulties can be remedied by improved planning and design.

The principal conclusions which may be drawn from the responses received on the operations section is that improved route design and operation procedures would be beneficial to most if not all of the school jurisdictions.

2.5 SUMMARY OF NEEDS

Based on the evaluations summarized in Section 2.4 the following needs have been identified:

- To establish policy guidelines for the provision of pupil transportation services and to establish well defined roles, duties and responsibilities for the administration of pupil transportation.

- To include a more detailed transportation impact evaluation when the location of a new school is being finalized.

- To establish service criteria to be used by all school boards for planning, monitoring and evaluating pupil transportation service.

- To attempt to create a systematic approach for planning school bus routes and to make this approach consistent in the province.

- To develop the methodology for quickly and accurately evaluating the impacts of alternative routing concepts on transportation costs, the level of service provided, etc.

- To provide school boards with data which will assist them in the proper planning of pupil transportation budgets for periods of up to three or even five years.

- To provide periodic seminars where information concerning pupil transportation matters can be discussed.

- To ensure that all drivers, whether board based or contractor hired participate in appropriate training programs.

- To ensure that school boards accept the principle that marginal changes to school operations should be made where the trade-off involves substantial improvements to the efficiency of pupil transportation systems.

- To establish procedures and criteria for the monitoring and evaluation of existing pupil transportation services.

In some instances, such as conducting seminars, the needs simply identify an area which should be given more attention at the present time by pupil transportation administrators. In other instances, to satisfy the identified needs, what is required is simply the dissemination of information to all people involved with pupil transportation. In still other instances the needs have identified areas where techniques should be developed in order to obtain the desired information.

Section 3 of this report addresses these latter two areas. The first part summarizes available information which will assist school jurisdictions in establishing transportation policies, and also some techniques which should assist in the planning, designing and monitoring of transportation services. The second part identifies those areas where additional information is required.

SECTION 3

PUPIL TRANSPORTATION MANAGEMENT

3.1 GENERAL

In order to understand the deficiencies and needs of the current pupil transportation services in the province it is important to identify clearly and describe what is the job to be done, the principal roles of individuals required to do the job, the duties and responsibilities of these individuals and the interrelationships which exist among the various groups involved. This section summarizes all of these starting with the organizational framework required to do the job and concluding with quidelines for designing bus routes.

Simply stated, pupil transportation involves the planning and operation of school bus routes. However to do this the transportation department must necessarily react to and provide input into policies which govern the level of service to be provided. Accordingly, for analysis purposes three separate areas of pupil transportation have been addressed; policy, planning and operations. Throughout this section specific reference will be made to each of these components.

3.2 ORGANIZATIONAL STRUCTURE

Although three discrete aspects of pupil transportation have been identified; policy, planning and operations, this does not necessarily imply that the responsibilities for these rest with three separate individuals or groups of individuals. The organizational structure required to administer pupil transportation will depend to a large

extent on local conditions peculiar to each school board. In general however, the policy issues are resolved by the board whereas the planning and operations issues are dealt with by one or more individuals.

It is beyond the scope of this report to recommend the organizational structure required to administer pupil transportation, however to define properly the job to be done, the principal roles have to be identified. Figure 1 conceptually illustrates the basic organizational roles and relationships which exist within a school jurisdiction.

It can be seen that two basic groups have been identified; a policy group (school board) and an administration group (transportation department).

3.2.1 Duties and Responsibilities of the School Board

The board should be responsible for the establishment of all policies relating to pupil transportation. Only the board is in a position to evaluate the impact of these policies in light of all other monetary demands which are being made on the entire school jurisdiction budget. The board must be willing to establish these policies considering the trade off which can be made with other priorities. Of course, in order to establish policies, information and feedback are required from the transportation department.

Policies established by a school jurisdiction (or in some instances policies governed by provincial regulations) to a large extent determine what the cost of the transportation service is going to be. Generally a school jurisdiction should establish two types of policies; one relating

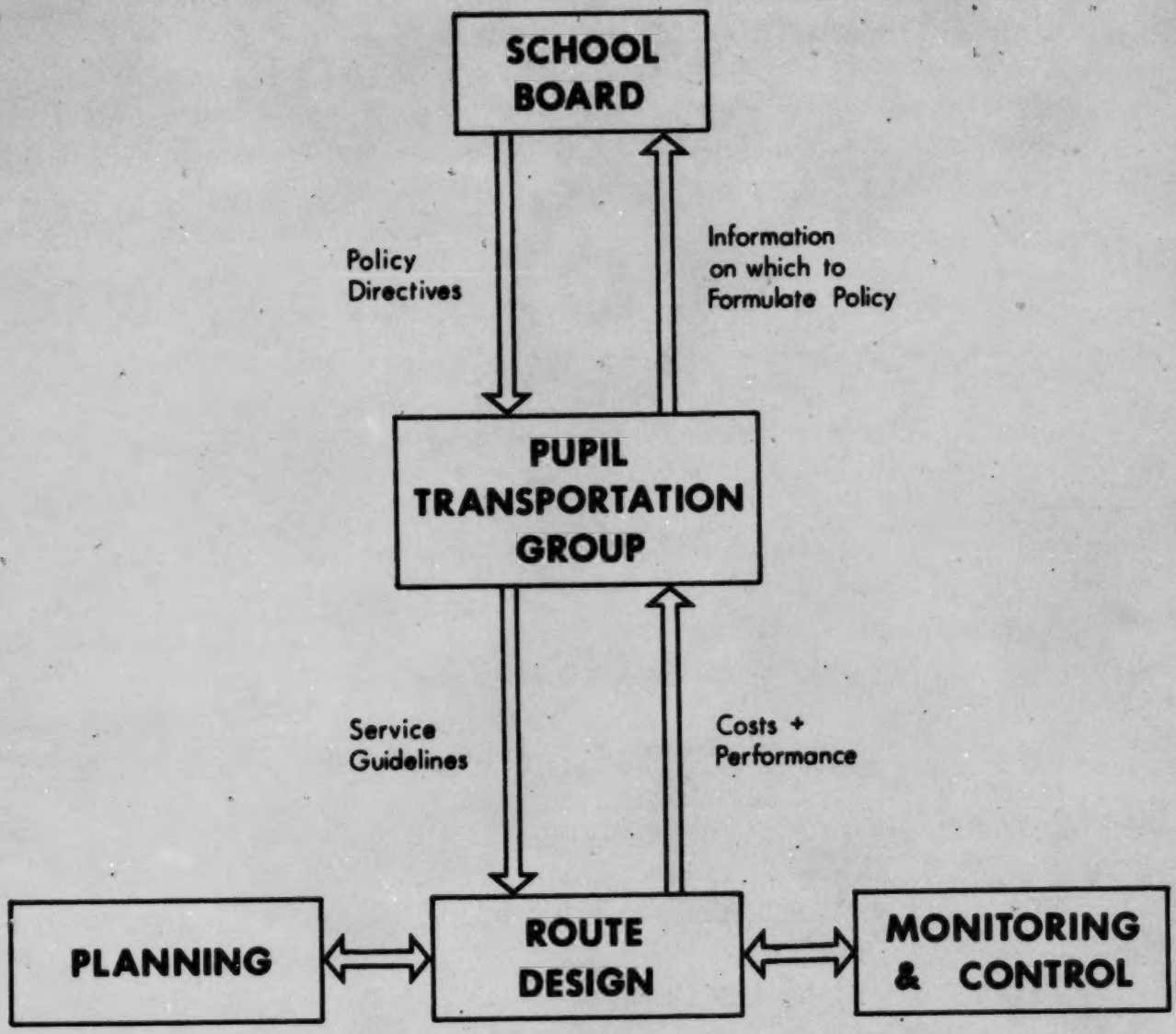

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Figure 1
ORGANIZATIONAL RELATIONSHIPS

to administration guidelines and one relating to quality of transportation service provided. Administration guidelines include such items as conduct of students on a board owned vehicle, hiring practices with respect to drivers, safety precautions which should be observed and board ownership of vehicles. In most instances with the possible exception of the board ownership policy these guidelines do not necessarily impact the cost of providing the transportation service.

Service policies on the other hand have a direct and measurable impact on cost. Service policies which a board should establish include:

- Maximum walking distance from a house or property line to a bus pick-up point.

- Eligibility of pupils for pupil transportation (i.e., distance from school).

- Maximum time spent on a bus by a student.

- Earliest possible pick-up time.

- Latest possible return time.

- Earliest arrival time at a school.

- Latest departure time from a school.

- Maximum number of students permitted on a bus (this could be segregated by age, grade, etc.).

- Permissible number of transfers.

- Cancellation of service (i.e., when is service withdrawn and for what reason, bad weather, etc.).

- Maintenance and service policies with respect to the buses (i.e., frequency of maintenance, cleaning, refurbishing).

The establishment of the above policies is vital because without them the transportation department has no guidelines on which to base the design of the bus routes. Therefore the resulting designs could be too generous i.e., too costly for the service provided, or provide a lower level of service than that in other areas of the province. Throughout this report it will be seen that policies established by the board are interrelated to almost every other activity relating to pupil transportation.

3.2.2 Duties and Responsibilities of the Transportation Department

This individual or these groups of individuals should be responsible for the administration and implementation of the policies established by the board. In addition, they should be providing information and feedback to the board in order to assist them in establishing policies. Specific duties which are performed include:

- Providing the board with information to assist it in developing policy.

- Preparing capital and operating budgets.

- Planning for new or improved transportation services.

- Designing bus routes.

- Monitoring and controlling existing bus routes.

- Negotiating contracts for non board owned vehicles.

- Supervising board drivers and maintenance facilities.

- Evaluating and recommending new equipment purchases.

- Evaluating and recommending policies toward board ownership of vehicles.

- Monitoring contract operations.

3.3 PLANNING

In simple terms pupil transportation planning involves estimating bus fleet requirements over specified planning periods. From this annual budgets can subsequently be developed.

Planning is essential in order to estimate the demands on the transportation system over a number of years. In particular planning is vital to estimate the impacts due to changes in board policy.

Planning is needed for the following reasons:

- To estimate demand on the system in the future and the resources required to accommodate this demand.

- To maintain bus fleet utilization at an acceptable level, one which conforms to board policy.

- To maintain or provide levels of bus service to standards equivalent to board policy. This would include decisions on making route changes, establishing new routes and so on.

- To provide input into new bus fleet purchases. (ie., number and type of vehicles required).

- To assess pros and cons of board ownership and operation of vehicles.

- To evaluate implications of changes in board policies.

- To estimate changes in the characteristics and distribution of the pupil population served.

- To assist with other activities of the administration which require or should require transportation input such as locations and sizing of new schools and the establishment of school catchment areas.

3.4 OPERATIONS

Operations deal with the day to day activities required to run or operate a pupil transportation system. Several components are involved but basically the principal aspect relates to establishing bus routes and monitoring their performance. With the exception of the establishment of service policies, operations is the most important aspect of pupil transportation management since total costs are directly related to the efficiency of the school bus routes. For this reason a majority of a transportation department's time should be spent on designing, monitoring and modifying bus routes.

3.4.1 Designing Bus Routes

Two basic methods currently exist for designing bus routes;

- manual methods
- computer assisted methods

In Alberta the manual methods are overwhelmingly predominant. In fact our survey indicated that to date, although some school jurisdictions are experimenting with computerized bus routing models, no one has used these for day to day operation.

From the personal interviews conducted and from the responses received to the questionnaire, it was apparent that each school jurisdiction in Alberta is unique in some aspect such as the network and conditions of the roads serving the area, differences in terrain or climate, the distribution of pupils, the density of population and the location of the schools serving the district. For this reason it is impossible to specify in detail how a route designer in a particular jurisdiction should approach his task. Conditions vary considerably across the province, some presenting the opportunity of more straightforward approaches than others. However it is possible to identify the principal and more common techniques which are available to assist a route planner and the systematic approach which should be employed in developing bus routes.

In general the route planning process can be divided into four components:

- Data collection and preparation
- Initial route design
- Evaluation of initial design
- Monitoring and control of established routes

The techniques and concepts which are used to complete each of these four components are discussed in the following sections[2]

3.4.2 Data Collection and Preparation

Initially, before any route planning is done information is collected regarding a number of parameters which either directly or indirectly impact on the probable route plan selected.

Of primary importance in route planning is the establishment of the number and location of students to be bused. For immediate requirements this is usually done through a survey of pupils which require transportation on an individual school basis. This is necessary in rural areas because often the postal address of the pupils do not contain sufficient information to permit the route planner to identify a residence to the tolerance limits required for planning. Usually a form is prepared for each student which records the name and address of the student (a small map indicating the exact student location would help) school attended and grade.

For long range planning purposes projections of pupils to be bused can be obtained by combining several sources of information including; expected student promotions, immigration and emigration projections for a given area, trends in residential construction starts, demographic trends with respect to increases and/or decreases in family sizes, birth rates, fertility rates and mortality rates, zoning changes, planning projections, etc.

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(2) The techniques and concepts outlined in this section have been largely drawn from two publications:

- Managing School Transportation prepared by School Business and Finance Branch, Ministry of Education, Ontario in conjunction with Peter Barnard Associates, Toronto, Ontario, February 1973.
- Transportation Management Handbook, University of the State of New York, the State Education Department, Albany, N.Y. 1967.

In addition to the name and location of each student the name, location and grades offered for each school in the jurisdiction should also be recorded. This information is compiled in a format which will permit easy storage, retrieval and analysis. In particular the information should be in a form in which it can preferably be used directly for designing bus routes.

The student data can be stored in one of two ways:

- Individual card files
- Computer file

The individual card file system is essentially a manual system in which a cardboard card file is prepared for each student requiring transportation. All relevant data indicated above is included in the file and if possible a small map of each student's location is included somewhere on the card. This would particularly aid in determining a rural location more explicitly. The advantages of this system are that it is simple to use and store and no special processing equipment is required. The disadvantages to this system is that considerable clerical time is required to update and modify the individual card files.

With a computerized system, essentially the same information is stored except that instead of a map a co-ordinate grid system is used which locates each residence to the tolerance required by the service guidelines established for designing bus routes.

When information is required a printout of the stored data can be made and the information used for route design purposes.

For designing bus routes some of the collected information has to be transfered to a map so that alternative routing concepts can be evaluated. Several methods are available for this, the most common

of which can be referred to as the pushpin system, the colored disc system and the overlay system.

In the pushpin system each student requiring transportation is marked on a school jurisdiction map by means of coloured pushpins, each pin being representative of a location where pick-ups are required. Pin colours can designate the school attended by the pupil. The number of students to be picked up at a location can be attached to the pushpins. School locations are also indicated on these maps.

A variation of the pushpin method is the coloured disc method, where self adhesive coloured discs are attached to the base map instead of pushpins.

The overlay system is similar to the pushpin system except that clear plastic acetate overlays are used to record the information. With this system no information is recorded directly onto the base map. A clear plastic overlay is prepared for the school locations and one for the locations of the pupils requiring transportation. Unlike the pushpin or coloured disc system, this method permits working copies to be made of any combination of overlays for the route designer.

Information is also collected on factors which impact the routing selected for each bus. This information includes number and type of roadways, condition of each roadway, bridge loading restrictions, locations of unprotected and protected railway crossings, traffic volumes on the principal roadways within the jurisdiction, locations of steep gradients and any other factor which is deemed to apply. This information can all be stored on a map of the school or board jurisdiction area depending on the volume of information which must be stored.

3.4.3 Initial Route Design

Following the determination of the number of pupils to be bused an initial estimate of the fleet size required to accommodate this demand is made. This is based on average bus loadings recorded in that particular jurisdiction in the previous year. This provides an initial estimate of the number of routes which will be required to accommodate the forecast demand.

Using this information a preliminary route system can be developed using some of the basic routing techniques outlined in Appendix C.

3.4.4 Evaluation of Initial Design

The preliminary route system developed is evaluated, firstly on the basis of the design parameters established to reflect board policy and secondly on other route evaluation measures which may be adopted by an individual school jurisdiction.

For example the route system is checked to estimate the maximum vehicle loadings, maximum walking distance to a pick-up point etc. The entire system is checked for adherence to criteria such as cost of providing the service, total student-bus kilometers of travel, total bus deadhead kilometers and so on. After several years of recording this data 'benchmark' values for these criteria can be established.

The planned bus routes are revised to conform with the noted changes and the process is reiterated until the designer is satisfied that further refinements would not produce more efficient routes.

3.4.5 Monitoring and Control of Established Routes

Once a route system is implemented surveys should be carried out to determine how effectively the routes are fulfilling the desired design conditions. By means of a field survey which is either administered by transportation department personnel or by the bus driver, information can be obtained on whether routes are starting too early or too late, overcrowding is apparent on vehicles, distances travelled coincide with the estimates, unsafe maneuvers are necessitated by the routing scheme and so on. These items can only be assessed properly by a field measurement.

3.5 COMPUTERIZED ROUTE DESIGN

The systematic approach used in a computerized route design model is similar to that outlined above for the manual means. The differences are only in the format in which the data is stored and input into the program.

For one, student and school locations are identified by co-ordinate numbers which refer to a grid superimposed on a map of the school jurisdiction. Also, route concepts are not input by the designer but rather are generated by a mathematical algorithm which systematically develops a routing scheme based on a number of optimizing parameters input into program.

The principal advantage of using computer models is that it permits the generation of a number of alternative route concepts by simply changing the optimizing parameters (i.e., walking distance, total distance travelled, etc.).

To date, no studies have been done in Alberta to compare the relative efficiencies of computer generated designs with those generated manually by experienced route designers. Documentation (3) on comparisons done elsewhere is limited, and the reported results are inconclusive. With the evaluation completed to date it appears that under the best circumstances computerized routing models are equivalent to manual routing procedures. It should be noted, however that computerized models do not necessarily eliminate the need for experienced route planners since all models require manual 'fine tuning' of the routes produced.

Based on the minimal evidence available to date it cannot be concluded that computerized routing models have a high priority for immediate implementation in Alberta school systems. Considering the current state of the art of route planning and design in the province, improvements and refinements to the manual procedures currently used would appear to offer more benefits.

However, the potential benefits to be gained from the development or adaptation of an efficient, working, computerized routing model are such (in particular the capability to evaluate quickly alternatives, especially changes in service policies) that the implementation of a pilot project in a selected school jurisdiction is warranted. This pilot project would compare route designs based on a current manual procedure and on computerized procedures and then evaluate costs, problems encountered, deficiencies in programs, etc.

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(3) Tracy, G.S. and Norman, M.J., A Computerized System for School Bus Routing, Ontario Institute for Studies in Education, Toronto, Ontario 1970

3.6 DATA REQUIREMENTS FOR PUPIL TRANSPORTATION MANAGEMENT

Regardless of the methodology used (computer or manual) the systematic route design approach outlined in Section 3.4 requires common background data. The actual data requirements and the methodologies used to collect the data vary somewhat between the planning and operations activities.

For planning purposes the following data is required:

- Number of pupils requiring transportation for each planning year.
- Fleet size required to accommodate this demand.
- Additions of new schools to a school area.
- Changes in location or closure of existing schools.
- Changes in roadway network.
- Cost trends for both variable and fixed cost components.

With this data transportation budget estimates can be prepared for any number of years.

For route design purposes more detailed information is required. A list of this information by category follows:

Students

- location
- grade
- school attended

School

- location
- grades offered
- catchment area
- no. of pupils in attendance
- no. of pupils which require transportation

Fleet

- make, model, serial number of each bus
- no. of buses in fleet (separate by regular and buses used for spares only)
- size
- location of storage (this is particularly important if the board does not own the vehicles and they are taken home by the contractor/drivers)
- owner of bus

Roadways

- classification of each roadway within a school jurisdiction (i.e., primary highway, secondary highway paved or unpaved, county road etc.)
- locations of bridges along with permitted loadings
- conditions of each roadway preferably based on a field reconnaissance by the transportation staff

Finally for monitoring and control information is required on the performance characteristics of the designed routes. This includes:

- Crowding conditions on the bus (i.e., maximum seated load)
- Adherence of routes and vehicle fleet to established designer parameters.

The above information needs are summarized and compared in Table 1 for route design, route planning and monitoring and control.

The table indicates that the information needs are similar for each of the three activities and in many cases the information required overlaps from one area to another. Differences occur not in the information itself but rather in the means used to obtain the data and the relative accuracy required from the data. These sources of data are more clearly illustrated in Table 2 which identifies how and where the required information may be obtained.

3.7 PLANNING AND ANALYSIS NEEDS FOR PUPIL TRANSPORTATION MANAGEMENT

Figure 2 schematically illustrates the information flow pertaining to pupil transportation in a typical school jurisdiction. Starting from the top it may be seen that the school board requires certain information upon which to base its policy decisions. The transportation department supplies this information. In order to do so, the transportation department has to perform some tasks; primarily route

Table 1 - Information Needs

	Route Design	Route Planning	Monitoring & Control
Students	- number - location - grade - school attended	- number - location - grade - school attended	- number carried by route
School	- location - grades offered - catchment area - no. of pupils in attendance - no. of pupils which require transportation	- location - grades offered - catchment area - no. of pupils in attendance - no. of pupils which require transportation	- location - no. of pupils which require transportation
Fleet	- make, model, serial number - no. of vehicles in fleet (separate board owned and contracted) - size - location of storage - owner of vehicle - maximum speed	- no. of vehicles in fleet - location of storage	- no. of vehicles in fleet - distance travelled by each vehicle and by fleet as a whole
Roadways	- classification - loading restrictions - conditions - posted speed limits	- principal roadway network	- principal roadway network - average speed on individual roadway links

Table 2 - Sources of Information

	Route Design	Route Planning	Monitoring & Control
Students	- field survey of each school where pupils require transportation - catalogue, store and update in a file	- expected pupil promotions - immigration and emigration to/ from school catchment area - trends in residential construction starts - demographic trends with respect to increases and/or decreases in family sizes, birth rates, fertility rates and mortality rates - zoning changes - planning projections - trends in pupil enrolment	- field survey of each bus route in operation
Schools	- field survey of each school where pupils require transportation	- pupil population projections from above - planning projections - zoning changes	
Fleet	- catalogued information	- pupil population projections from above - average load factors from monitoring and control activities	- field survey
Roadways	- field survey	- Alberta Transportation - Municipal or County Engineering Departments	- field survey

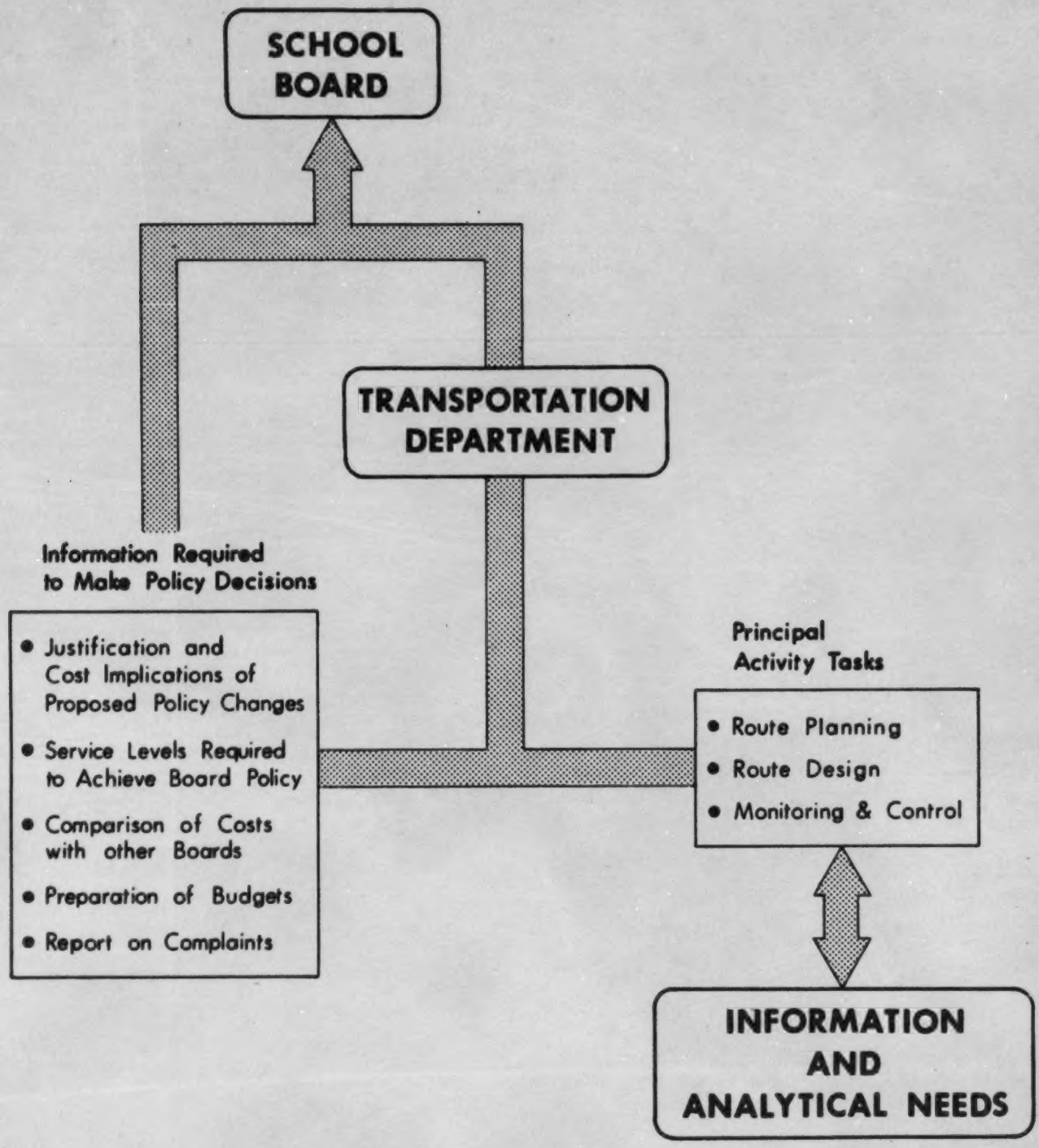
SCHOOL BOARD
TRANSPORTATION DEPARTMENT
Information Required to Make Policy Decisions
• Justification and Cost Implications of Proposed Policy Changes
• Service Levels Required to Achieve Board Policy
• Comparison of Costs with other Boards
• Preparation of Budgets
• Report on Complaints
Principal Activity Tasks
• Route Planning
• Route Design
• Monitoring & Control
INFORMATION AND ANALYTICAL NEEDS

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Figure 2
INFORMATION FLOW

planning, route design and monitoring and control of routes. In order to perform these tasks there are information and analytical needs for each of the three activity tasks. The information needs have been identified in Tables 1 and 2.

Using Tables 1 and 2 three areas can be identified which are time consuming, are data-intensive and are readily adaptable to automation (i.e., principal candidates for inclusion into a planning and analysis package for Alberta school systems). These are:

- Collection, storage and retrieval of data pertaining to the characteristics of each pupil requiring transportation.

- Estimating the number and location of pupils which will require transportation at some point in the future.

- Designing bus routes.

3.7.1 Priority Development Schedule of Needs

Based on the needs expressed by the school boards in Section 2, on the expected ease of implementation of each of the above and the expected benefits to be gained from each of them, a priority development schedule has been established as follows: data storage and retrieval system, pupil forecasting model and computerized bus routing model.

The first priority is to establish a system of recording and storing data which is easy to use and implement and available to all users. Data storage and processing is readily adaptable to computerization.

Initially data storage should consist of:

- Pupil name
- Pupil address (coded for routing purposes)
- School attended
- Grade
- Current bus route on which pupil is transported
- Distance (by road) to school
- Current travel time to school.

Once stored this information can be easily updated. When required, periodic printouts of the information can be made of items such as: all pupils travelling on a specific bus route, pupils requiring transportation by school or grade, maximum, minimum or average distances travelled and maximum, minimum or average travel times.

The advantages of such a system are obvious. It has been estimated(2) that each year between 25% and 30% of the pupils being transported will change due to promotions, transfers, immigrations and emigration. Therefore in a school district which transports say 7,000 students, the annual changes which should be made to the student file number approximately 2,000. Much clerical time can be saved by the adoption of this system.

The second priority, the pupil forecasting model, is one which can be used in conjunction with the data storage model to produce preliminary pupil population and location projections which can be used for planning purposes and for establishing budgets.

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(2) Managing School Transportation, prepared by School Business and Finance Branch, Ministry of Education Ontario in conjunction with Peter Barnard Associates, Toronto, Ontario 1973.

Finally, the third priority; a computerized routing model, would use the data developed from the first two models to generate alternative routing concepts and their associated costs.

Brief work programs have been prepared for the development of each of the above models. These are summarized in Section 4.

SECTION 4

DEVELOPMENT OF PLANNING AND ANALYSIS PACKAGE

4.1 GENERAL

As indicated in Section 1 one of the tasks of this report was to identify informational or analytical techniques which would be used to assist Alberta school jurisdictions in planning for pupil transportation. These techniques were identified in Section 3. A work program for the development of these techniques is presented in this section.

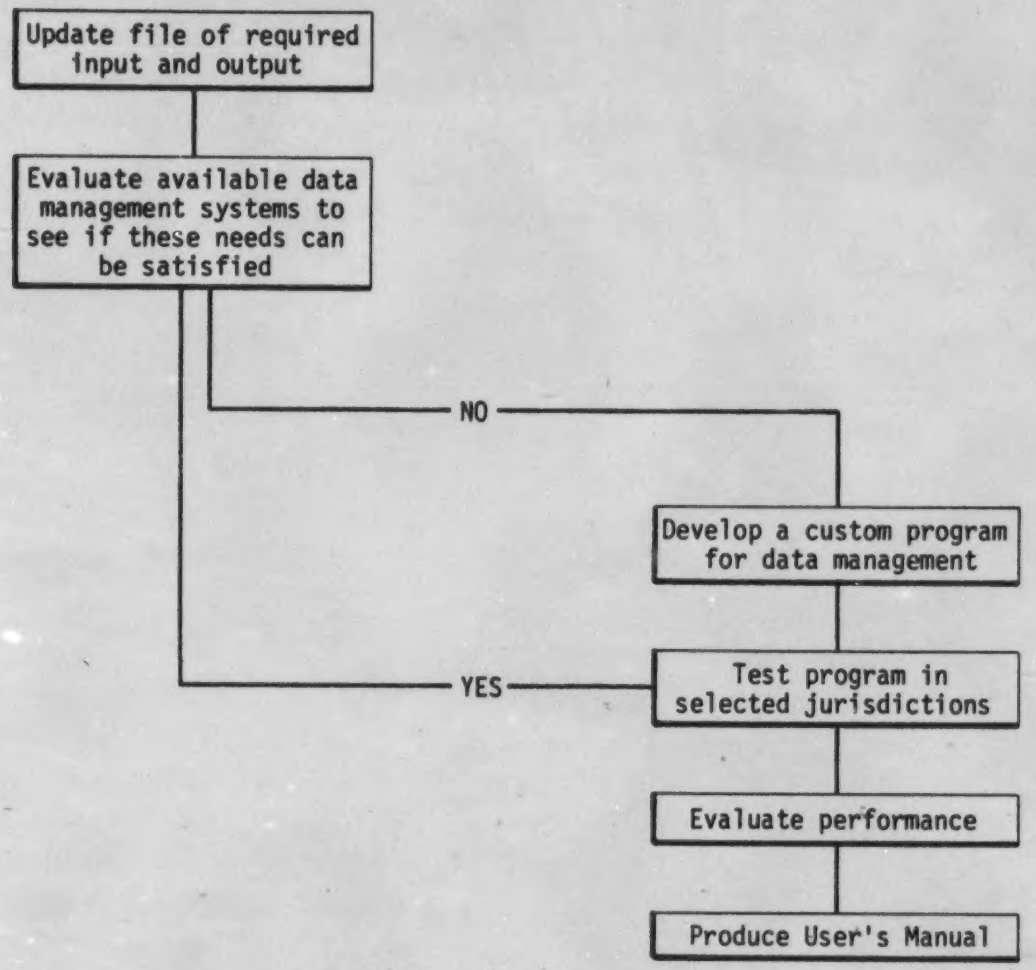
4.2 DATA STORAGE AND RETRIEVAL SYSTEM

A new processing program will not necessarily have to be developed for this activity. Several data management systems are available in the province which will permit the required information to be stored and retrieved without any modifications. These systems, available from private computer service firms, are only limited by the output format required by each school jurisdiction. In any event, even if a custom program has to be developed, the programming requirements are not too demanding.

Figure 3 schematically illustrates the principal activities which must be performed to develop this system.

The estimated costs for the above program development will depend on whether or not available data management systems can be used or not. If existing systems can be used the estimated cost is approximately $15,000, excluding any data collection activities. If a custom program has to be developed an additional $5,000 would be required.

FIGURE 3
DATA STORAGE AND RETRIEVAL SYSTEM
ACTIVITY FLOW DIAGRAM


Update file of required input and output
Evaluate available data management systems to see if these needs can be satisfied
NO
YES
Develop a custom program for data management
Test program in selected jurisdictions
Evaluate performance
Produce User's Manual

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4.3 PUPIL FORECASTING MODEL

The methodology which will likely be used for this model is one similar to that used for long range transportation planning purposes. This methodology, commonly referred to as "the cohort-survival method", simply disaggregates current population into selected age and sex cohorts and then predicts future populations on the basis of demographic and immigration trends. Demographic parameters used include fertility rates and mortality rates. Immigration trends must be estimated and input into the procedure by age and sex cohorts.

This methodology is reasonably accurate since mortality and fertility rates can be estimated quite closely from past trends. However in areas of high immigration, such as the newly developing regions of Alberta, the accuracy of this parameter is reduced because of the difficulty in estimating these trends.

It is likely that methodologies similar to the cohort-survival method are already in use in most school jurisdictions in Alberta, especially the larger ones. Therefore, to implement this methodology for pupil transportation planning needs requires only integration into existing programs.

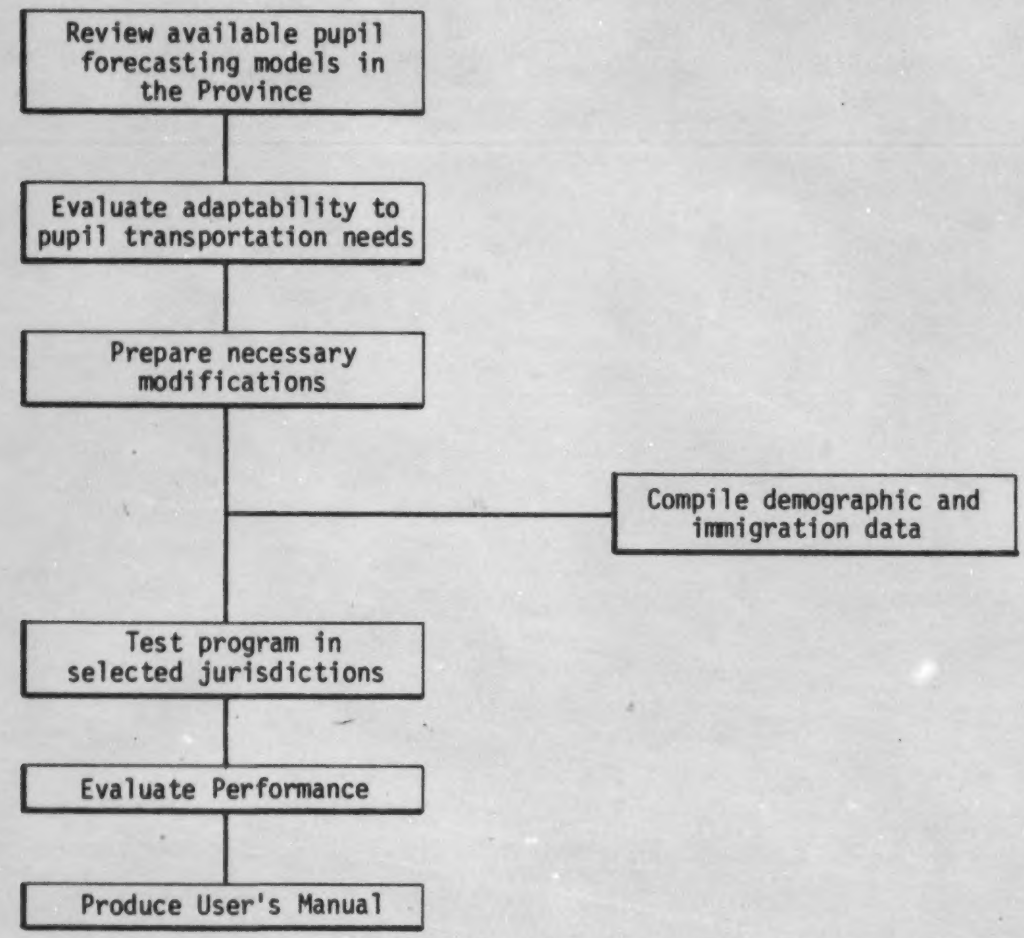
Of course modifications to a simple pupil forecasting model are required to make it applicable to pupil transportation. More specifically the model should be designed to attempt to predict the location of new students (i.e., immigrants) as well as shifts in existing populations. For this reason other inputs will be required such as land use plans, zoning changes, major industrial developments, etc. These parameters can be calculated manually and input into the program.

Figure 4 schematically illustrates the principal activities which must be performed to develop this program.

FIGURE 4

PUPIL FORECASTING MODEL

ACTIVITY FLOW DIAGRAM


Review available pupil forecasting models in the Province
Evaluate adaptability to pupil transportation needs
Prepare necessary modifications
Compile demographic and immigration data
Test program in selected jurisdictions
Evaluate Performance
Produce User's Manual

The expected costs of developing such a program is also approximately $20,000, excluding the data collection activities.

4.4 COMPUTERIZED ROUTING MODEL

As indicated earlier, the potential advantages of having a computerized routing model are such that its potential implementation into Alberta school systems should be investigated.

It appears that sufficient programs are currently on the market, that a new model would not necessarily have to be developed. The evaluation process in the province would consist of trial usages of available programs and comparison of the results with manual procedures. From the study survey responses it appears that several school jurisdictions would be interested in participating in such a demonstration program.

At the completion of the evaluation period a decision can be made on whether or not available programs appear to be viable or if a new model should be developed.

Figure 5 schematically illustrates the principal activities which must be performed to develop this system.

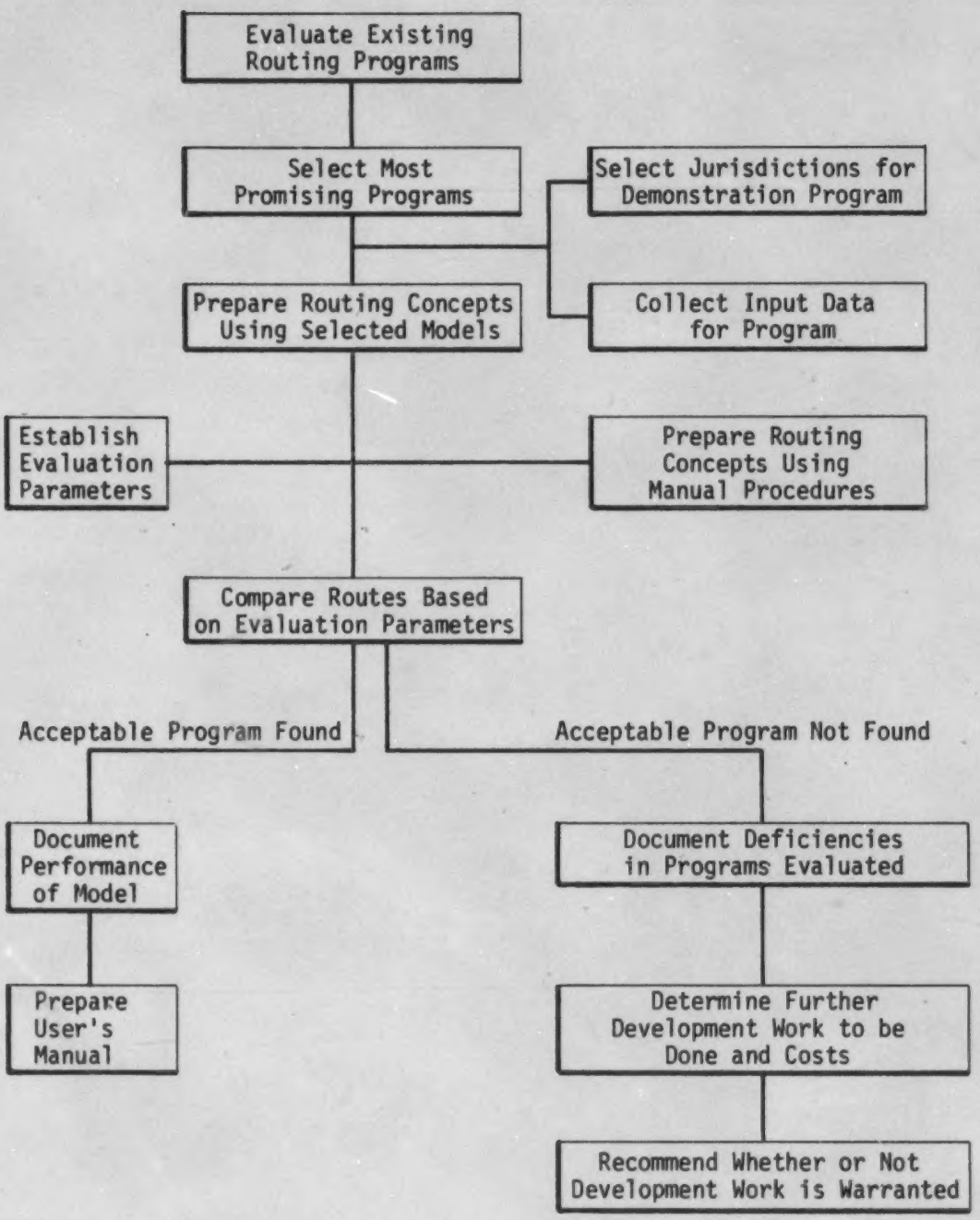
The expected costs of this model evaluation are considerably higher than the other two models because the amount of uncertainty in the expected results is higher. For this reason it is difficult to estimate a cost for this program development. However for planning purposes it should be expected that this work program will cost in the order of $40,000 to $45,000, excluding the data collection component.

For interested readers Appendix 'D' presents a summary of some of the more common computerized routing models under development or evaluation.

FIGURE 5

COMPUTERIZED ROUTING MODEL

ACTIVITY FLOW DIAGRAM


Evaluate Existing Routing Programs
Select Most Promising Programs
Select Jurisdictions for Demonstration Program
Prepare Routing Concepts Using Selected Models
Collect Input Data for Program
Establish Evaluation Parameters
Prepare Routing Concepts Using Manual Procedures
Compare Routes Based on Evaluation Parameters
Acceptable Program Found
Acceptable Program Not Found
Document Performance of Model
Prepare User's Manual
Document Deficiencies in Programs Evaluated
Determine Further Development Work to be Done and Costs
Recommend Whether or Not Development Work is Warranted

APPENDIX 'A'

Results of ASTA Conference Questionnaire

PUPIL
TRANSPORTATION
SURVEY

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1. What school system do you represent?

_____

2. Is there a specific department within your school system responsible for the planning and administration of pupil transportation?
Yes _____ No _____

3. When reorganizing existing schools or planning new ones, is consideration given to pupil transportation BEFORE, DURING, or AFTER the school location is selected?

_____

4. Would you alter your school operation to facilitate pupil transportation?
Yes _____ No _____

5. Please indicate which of the following are used in your school system to plan bus routes: ( )
   - Number of pupils per route. . . . . _____
   - Maximum travel time by any one pupil. . . . . _____
   - Maximum route mileage by any one bus. . . . . _____
   - Maximum bus stops per mile. . . . . _____
   - Maximum walking distance by a pupil to pick-up point . . . . . _____
   - Number of reloads or transfers. . . . . _____
   - Provision of gate service . . . . . _____
   - Highway traffic volumes . . . . . _____
   - Railway crossings . . . . . _____
   - Primary highway crossings . . . . . _____
   - Double tracking . . . . . _____
   - Back tracking . . . . . _____
   - Cross tracking. . . . . _____
   - Operating costs . . . . . _____
   - Other . . . . . _____

6. Is the Provincial PUPIL TRANSPORTATION GRANT PROGRAM considered when:
(Yes or No)
   - Planning school bus routes. . . . . _____
   - Purchasing new buses. . . . . _____
   - Establishing school attendance boundaries . . . . . _____
   - Establishing school size. . . . . _____
   - Establishing pupil in-bus travel time . . . . . _____
   - Determining total number of pupils to be bussed. . . . . _____
   - Determining the total number of school buses in the fleet. . . . . _____
   - Determining the capacity of each bus in the fleet . . . . . _____

7. Do you have a long-range plan for: (Yes or No)
   - Pupil transportation _____ - Facility requirements ____
   - Pupil enrollment _____ - Financing methods _____
   - Bus fleet characteristics ____ - Other _____

8. What is your ratio of:
Board owned buses _____ Contracted bus services _____

Is this a standing policy? Yes _____ No _____

9. How many complaints have you had in the past year with respect to pupil transportation?

_____

10. Please identify any major concerns with respect to pupil transportation in your school system. (Use reverse if necessary)

TABULATION OF RESULTS

Question #2: Special Department for Planning and Administration of Pupil Transportation

Eighteen of 26 responses stated that they had a specific department responsible for the planning and administration of pupil transportation. Of the 18 responses one stated that the group responsible was the transportation committee of the Board of Education and another was a group of school trustees.

Question #3: Consideration of Pupil Transportation Before, During, or After the Selection of School Location

	No. of Responses	% of Responses
Before	17	53
During	8	25
After	7	22
	32	100%

Note: 26 responses received, however 4 indicated all three and 1 indicated before and after.

Question #4: Would You Alter School Operations to Facilitate Pupil Transportation?

Sixteen (70%) of 23 respondents to this question stated that they would alter school operations if necessary to aid pupil transportation. The remaining 7 school districts replied negatively.

Question #5: Information Used to Plan Bus Routes

24 school districts responded to this question. The following is a summary of their replies.

Items	No. of Responses
1. Maximum Travel Time/Pupil	24
2. Operating Cost	20
3. Maximum Walking Distance to Pickup Point	19
4. No. Pupils/Route	18
5. Provision of Gate Service	16
6. Double Tracking	16
7. Maximum Route Mileage by One Bus	15
8. Back Tracking	15
9. Railway Crossings	14
10. No. of Reloads/Transfers	13
11. Primary Highway Crossings	12
12. Highway Traffic Volumes	8
13. Cross Tracking	
14. Others	7
15. Maximum Bus Stops/Mile	6

Note: 100% of the respondents stated that they considered maximum travel time/pupil when planning bus routes.

Question #6: When is the Provincial Pupil Transportation Grant Program Considered?

The respondents to this question (24 in total) stated that when the following items were looked at the Grant Program was considered.

Items		No. of Responses
1.	Determine Capacity of Each Bus in Fleet	23
2.	Planning School Bus Routes	19
3.	Purchasing New Buses	19
4.	Determining Total Number of Buses in Fleet	18
5.	Establishing Pupil On-bus Travel Time	11
6.	Determining Total Number of Pupils to be Bused	11
7.	Establishing School Attendance Boundaries	8
8.	Establishing School Size	5

Question #7: Long Range Plans (24 Responses)

Items		No. of Responses
1.	Pupil Enrolment	10
2.	Financing Method	10
3.	Bus Fleet Characteristics	9
4.	Pupil Transportation	7
5.	Facility Requirements	7
6.	Other	0

Note: 4 districts plan for all five items.
2 districts plan for three items.
5 districts plan for two items.
7 districts plan for one item.
6 districts plan for 0 items.

Question #8: What is the Ratio of Board Owned Buses/Contracted Bus Service (26 Responses)

Of the 26 responding school districts, 13 stated that 75% of their buses are school board owned, and 11 stated that 75% of their buses are from contract bus services.

If all the percentages are added for each section, 51% of the buses are school board owned, and 49% are contracted from bus services.

Question #9: Number of Complaints Received (26 Responses)

Unfortunately not all of the responses to this question indicated the approximate number of complaints. Some preferred to use descriptive terms. The description used may be summarized as follows:

- None - 4
- Few - 18
- Many - 4

Question #10: Areas of Major Concerns

The major areas of concern are listed below, beginning with the area which was of most concern to the school trustees.

Items	No. of Responses
1. Grant Formula and Funding	11
2. Safety	7
3. Routes/Routing/Gate Service	7
4. Load Factors	5
5. Rated Capacity of Buses (Re-classification)	3
6. Larger Buses Needed/Better Chassis	2
7. Riding Time/Scheduling	2
8. Mobile Radios	2
9. More Training and Experienced Supervisors	1
10. Support for In-Town Bussing	1
11. Support for Extra-curricular Activities/ Between School Transport	1

APPENDIX 'B'

Survey Form

JURISDICTION: _____

SECTION A - ORGANIZATION

1. WITHIN YOUR SCHOOL SYSTEM, PLEASE INDICATE:

Name and/or title of individual or department in charge of the planning, and administration of pupil transportation.

_____

Name and/or title of his immediate superior _____

Number of staff within the department (if applicable) _____

Please give a brief description of the individuals or departments organizational duties and responsibilities. (If there is a job description please attach a copy.)

SECTION B - PLANNING

2. WHEN REORGANIZING EXISTING SCHOOLS OR PLANNING NEW ONES, IS CONSIDERATION GIVEN TO PUPIL TRANSPORTATION *BEFORE*, *DURING* or *AFTER* THE SCHOOL LOCATION IS SELECTED?

_____

Please indicate how this consideration is given:

3. PLEASE INDICATE WHICH OF THE FOLLOWING ARE USED IN YOUR SCHOOL SYSTEM TO PLAN BUS ROUTES. FOR EACH ONE THAT IS USED ALSO INDICATE WHAT THE CRITERION IS AND WHETHER IT IS A STANDING BOARD POLICY OR A GUIDELINE USED BY THE BUS ROUTE PLANNER.

- Number of pupils per route ( )
  What is number used? _____
  Board Policy _____ or Guideline _____

- Maximum travel time by any one pupil ( )
  What is the maximum? _____
  Board Policy _____ or Guideline _____

- Maximum route distance by any one bus ( )
  What is the maximum? _____
  Board Policy _____ or Guideline _____

- Maximum bus stops per mile (Kilometer) ( )
  What is the maximum? _____
  Board Policy _____ or Guideline _____

- Maximum walking distance to a pick-up point ( )
  What is the maximum? _____
  Board Policy _____ or Guideline _____

- Maximum number of reloads or transfers ( )
  What is the maximum? _____
  Board Policy _____ or Guideline _____

- Railway and Primary Highway Crossings ( )
  How are these considered?

- Operating Cost ( )
  How is this considered?

- Double Tracking, Cross Tracking or Back Tracking ( )
  How are these considered?

- Traffic Volumes ( )
  How is this considered?

- Grade levels of pupils ( )
  How is this considered?

- Is gate service provided* Rarely, Occasionally or Often? _____
  Board Policy _____ or Guideline _____

- Other

*Gate service is the provision of pupil transportation services up to the front gate of rural properties.

4. WITH YOUR SCHOOL SYSTEM'S PRESENT BUS ROUTING:

What is a) the longest and b) the average, approximate period of time that any one pupil spends on a bus?

Longest _____ Average _____

5. BASED ON THE CURRENT METHODOLOGY USED IN YOUR SCHOOL SYSTEM TO PLAN SCHOOL BUS ROUTES, PLEASE INDICATE HOW USEFUL YOU FIND EACH OF THE FOLLOWING WHEN PLANNING SCHOOL BUS ROUTES:

	Not Useful	Moderately Useful	Very Useful
. County or city road map			
. School location map			
. School attendance area map			
. Name and address of each pupil			
. Type of roadways and condition based on:			
a) field inspection report of all roadways within school district			
b) county or provincial roadmaps			
. Grade level of each student			
. Daily school opening and closing times			
. School class schedules			
. 85 percent load factor, required for Alberta Education funding assistance			
. $100 per pupil funding assistance			
. Police accident records			
. Traffic volumes			
. Location of Railway or major highway crossings			
. Other (please specify)			

6. PLEASE SUMMARIZE THE METHODOLOGY USED BY YOUR SCHOOL SYSTEM TO PLAN PUPIL TRANSPORTATION.

7. HOW USEFUL WOULD EACH OF THE FOLLOWING BE IN ASSISTING YOUR SCHOOL SYSTEM TO PLAN PUPIL TRANSPORTATION SERVICES:

	Not Useful	Moderately Useful	Very Useful	Presently Available
Computerized school bus routing models	_____	_____	_____	_____
Short and long range projections for:				
- pupil populations within each school system	_____	_____	_____	_____
- population shifts	_____	_____	_____	_____
- fleet size	_____	_____	_____	_____
- facilities	_____	_____	_____	_____
- financial	_____	_____	_____	_____
- other	_____	_____	_____	_____
Monthly updates of names, addresses and grade levels of each pupil requiring transportation	_____	_____	_____	_____
The capability to evaluate quickly the impacts of alternative bus routing plans	_____	_____	_____	_____

8. DO YOU CURRENTLY HAVE A LONG RANGE (5 YEARS OR MORE) PLAN FOR: (YES OR NO)

- Pupil transportation _____
- Pupil enrollment _____
- Bus fleet characteristics _____
- Facility requirements _____
- Financing methods _____
- Other _____

If "no" please indicate planning period used for projections for each of the above.

SECTION C - OPERATIONS

9. WOULD PERIODIC SEMINARS PROVIDING INFORMATION AND EXCHANGE OF IDEAS AMONG PERSONS RESPONSIBLE FOR PUPIL TRANSPORTATION SERVICES IN THE PROVINCE BE BENEFICIAL? PLEASE EXPLAIN:

10. DOES YOUR SCHOOL SYSTEM CURRENTLY HAVE A SCHOOL BUS DRIVER TRAINING PROGRAM? Yes _____ No _____

If "yes" is the program:

administered by the board _____ administered by a private firm _____

Other _____ name of firm _____

Briefly describe the training program.

11. ARE YOU PREPARED TO MODIFY SCHOOL OPERATION TO FACILITATE PUPIL TRANSPORTATION? Yes _____ No _____

If "yes" what modifications (if any) have already been made within your school system:

If "no" please state reason for objection:

12. WHAT IS YOUR RATIO OF:

Board owned buses _____ Contract Bus Service _____

If there is a standing board policy, what is the guideline _____

13. IS THE PUPIL TRANSPORTATION FLEET USED FOR TRANSPORTATION TO EXTRA-CURRICULAR ACTIVITIES AND SPECIAL PROGRAMS? _____ (Yes or No)

PLEASE ESTIMATE THE APPROXIMATE NUMBER OF EXTRA-CURRICULAR OR SPECIAL BUS TRIPS IN YOUR SYSTEM.

_____ Bus trips per week/or _____ bus trips per month/or _____ bus trips per year

Percentage of trips by board owned buses _____
Percentage of trips by contracted buses _____

Does the school board have a formal policy regarding the provision of these special services?
Yes _____ No _____

If yes, please indicate what the policy is:

14. PLEASE INDICATE THE IMPORTANCE OF THE ALBERTA EDUCATION'S PUPIL TRANSPORTATION GRANT PROGRAM WITH REGARD TO EACH OF THE FOLLOWING:

	Not Important	Moderately Important	Very Important
. Planning school bus routes	_____	_____	_____
. Purchasing new buses	_____	_____	_____
. Establishing school attendance boundaries	_____	_____	_____
. Establishing school size	_____	_____	_____
. Pupil in-bus travel time	_____	_____	_____
. Total number of pupils to be bused	_____	_____	_____
. Total number and sizes of school buses in fleet	_____	_____	_____

15. WOULD THERE BE ANY BENEFIT TO YOUR SCHOOL SYSTEM IF A CENTRAL AGENCY WAS ESTABLISHED IN THE PROVINCE TO BUY BUSES FOR ALL SCHOOL SYSTEMS IN ALBERTA? PLEASE EXPAIN.

16. WHAT IS THE IMPACT OF EARLY CHILDHOOD SERVICE ON THE PLANNING AND THE FINANCING OF THE OPERATING BUDGET FOR PUPIL TRANSPORTATION?

17. PLEASE LIST ANY PROBLEMS YOUR SCHOOL SYSTEM CURRENTLY EXPERIENCES WITH PUPIL TRANSPORTATION.

18. PLEASE INDICATE THE VARIOUS TYPES OF COMPLAINTS YOU HAVE HAD IN THE PAST YEAR WITH RESPECT TO PUPIL TRANSPORTATION.

19. ADDITIONAL COMMENTS.

APPENDIX `C´

Route Design Concepts and Techniques

ROUTE DESIGN CONCEPTS AND TECHNIQUES

The concepts and techniques outlined below will assist the route designer with developing alternative bus routing concepts[1].

C.1 TYPES OF ROUTES

There are two basic types of route layout. For each of these there are a further three routing techniques which can be used to improve efficiency.

The two basic types of route layouts are:

- Circular or one-way route
- Direct or two-way route

C.1.1 Circular or One-Way Route (Figure C-1)

This is a main or trunk route which circumscribes an area by using different roads on the out-going and incoming trips. On a given trip, none of the mileage is covered in both directions. This routing has the advantage of equalizing the time which pupils spend on the bus. This is accomplished if the bus travels in the same direction on each trip so that the first child on in the morning is the first off at night. In this type of route, the first children to board the bus are normally transported over a very indirect route before arriving at school.

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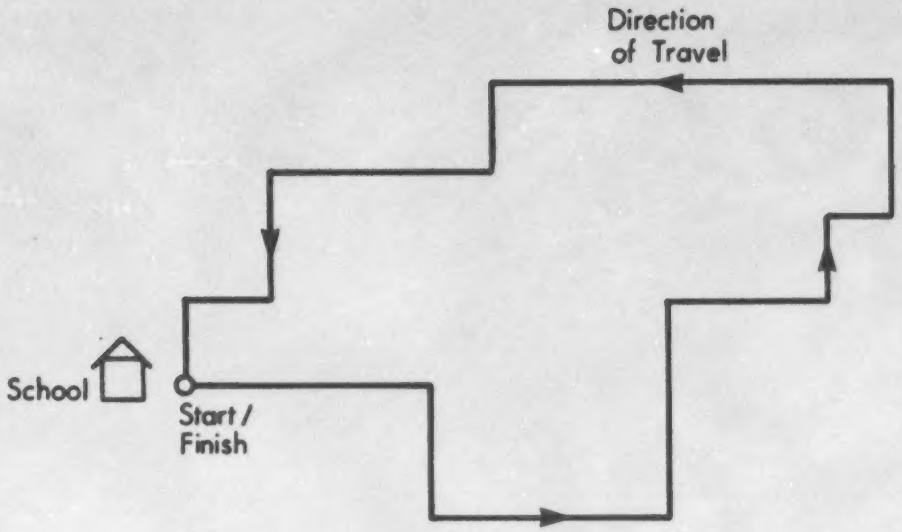
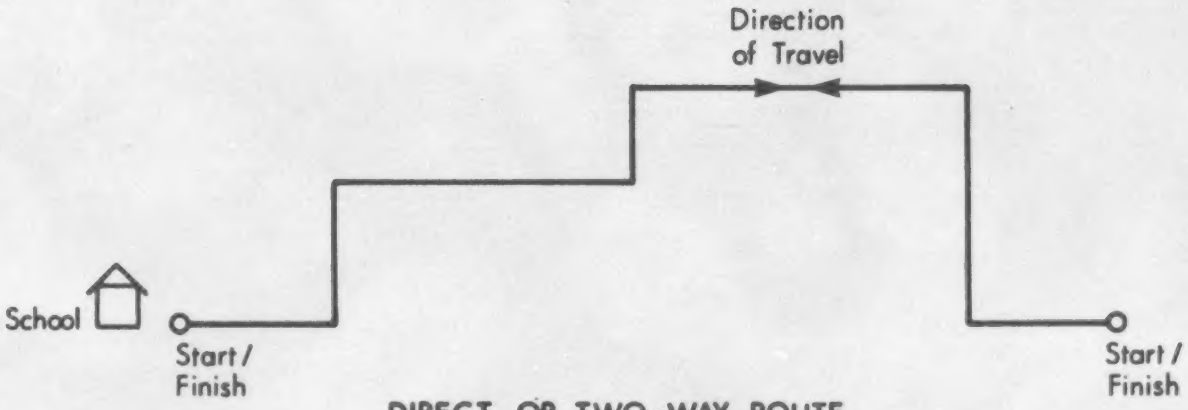
(1) This section is largely drawn from two references:

Transportation Management Handbook, University of the State of New York, the State Education Department, Albany, N.Y. 1967

Managing School Transportation, School Business and Finance Board, Ministry of Education Ontario, in conjunction with Peter Barnard Associates, Toronto, Ontario, 1973



CIRCULAR OR ONE-WAY ROUTE



DIRECT OR TWO-WAY ROUTE

Stanley

Figure C-1
BASIC ROUTE LAYOUTS

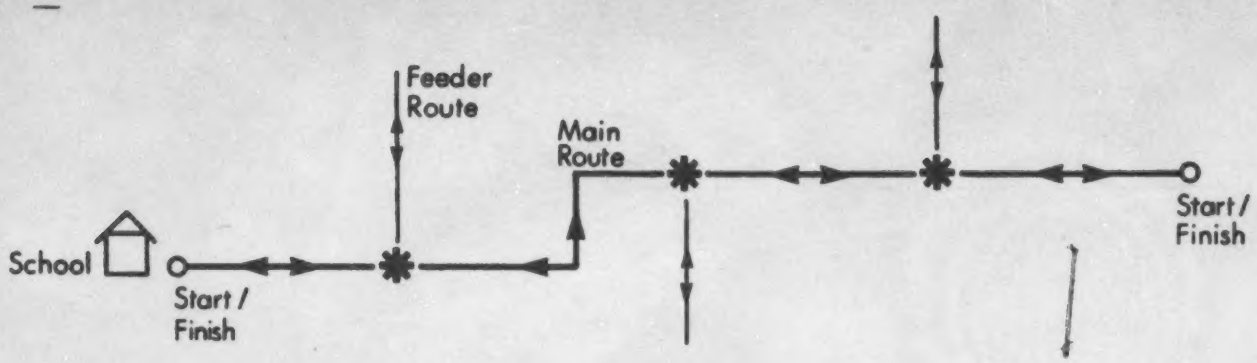
C.1.2 Direct or Two-Way Routes (Figure C-1)

This is a main route which extends from the school to some terminal point in the school district. Regardless of where the bus is stored, it uses the same roads for both the incoming and outgoing trips, that is, travels both ways on the same roads. On this type of route, the students travel more directly towards the school compared to the circular route. However, the first students on in the morning are also the last off in the afternoon. Accordingly, the time spent on the bus by all students cannot be equalized. The degree of "directness" of such routes can vary from a straight route between towns along a main highway to a less direct route picking up students throughout an area. In all instances however, the bus is heading more or less towards the school.

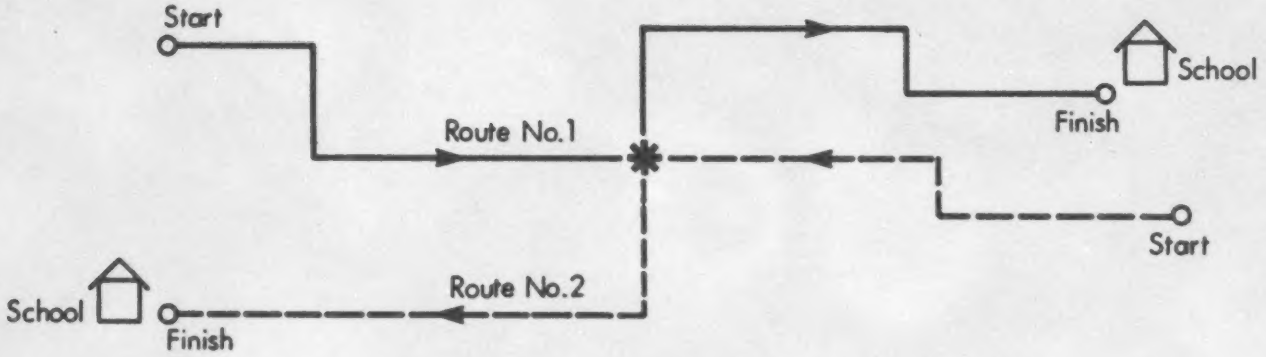
The designer may vary the two basic route types through the use of one or more variations or techniques which include the use of transfers, turnarounds and having the route serve more than one school. Each of these approaches has advantages, but can only be used when particular circumstances permit.

C.1.3 Transfers

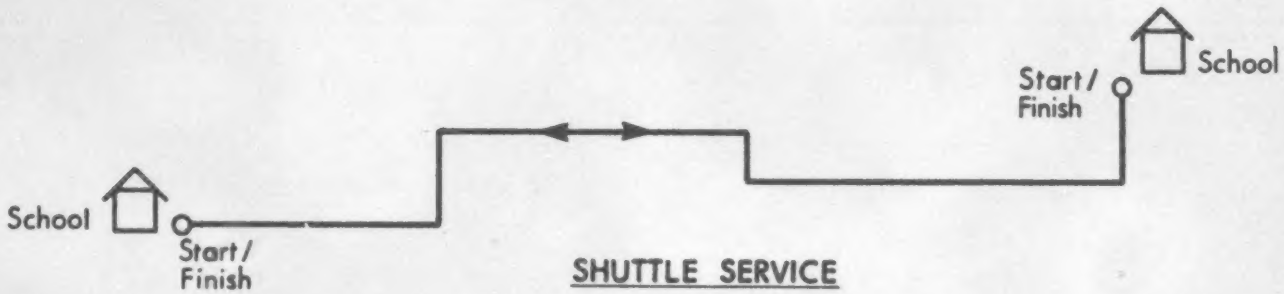
The two basic route types can be modified by introducing one or more transfer points along the route. As discussed previously the issue of whether or not transfers are permitted should be included as part of a school board's transportation policy. While often a useful technique for improving operating efficiency or shortening the time students spend on the bus, it should be remembered that a transfer effectively reduces the level of service provided on a route because of the inconvenience caused to the students. Also, transfer points have to be carefully located to ensure that the students can change buses safely. Three different approaches incorporating transfers can be used as illustrated in Figure C-2:



FEEDER ROUTES



INTERLOCKING ROUTES (Morning Run)



SHUTTLE SERVICE

DIRECTION OF TRAVEL

TRANSFER POINT

Stanley

Figure C-2
TYPES OF TRANSFER ROUTES

- Feeder Routes
- Interlocking Routes
- Shuttle Routes

Feeder routes can be used to pick up a relatively small number of students and then transfer them to buses travelling on more-or-less direct routes to school. This approach may be employed where relatively few students live on certain secondary roads and cannot be served using the main bus, either because the students are too far apart to be served economically, or because the roads are impassable for large buses. Any small vehicle including snowmobiles, cars, vans or small buses can be employed on such feeder routes.

Interlocking routes are used when it is desirable for two routes to cross and at that point to transfer students from one bus to the other or to exchange students between buses. The two buses then carry on to different schools. This approach may be necessary when the attendance areas are not regular in shape but in some way interlock, so that students at the farthest point from one school are picked up initially by a bus destined for a different school. Other features of the local road system and/or student distributions may dictate the use of interlocking transfer routes. The two routes which interlock may be either circular or direct routes.

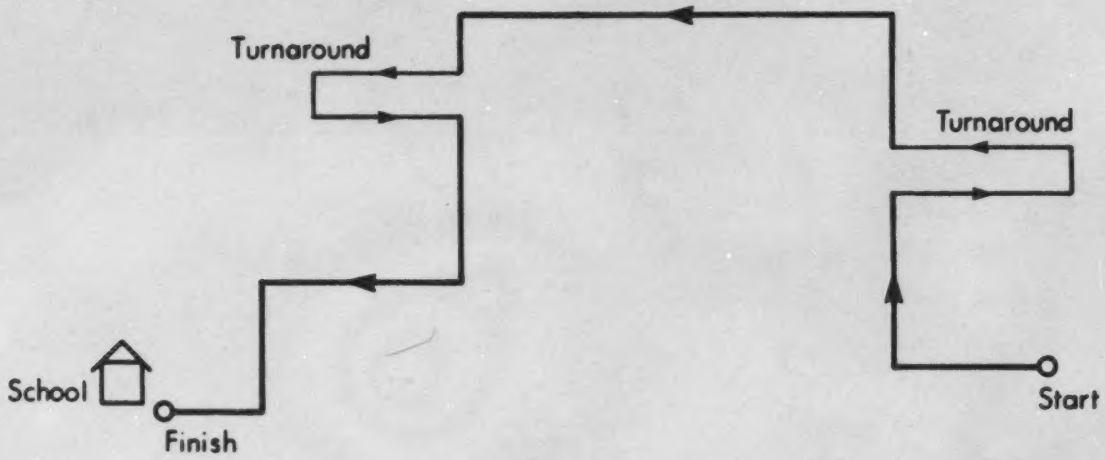
A shuttle route simply "shuttles" students between one school and another. With this concept, students are dropped off at one or both schools and a different bus (often one that has already completed a normal route) distributes the students to two or more nearby schools. This type of route is often introduced as an alternative to the multi-school route and can prove useful in areas where there are a number of schools. It is also employed during the day to transfer students from one school to special facilities or instructional programs in another school.

C.1.4 Turnarounds

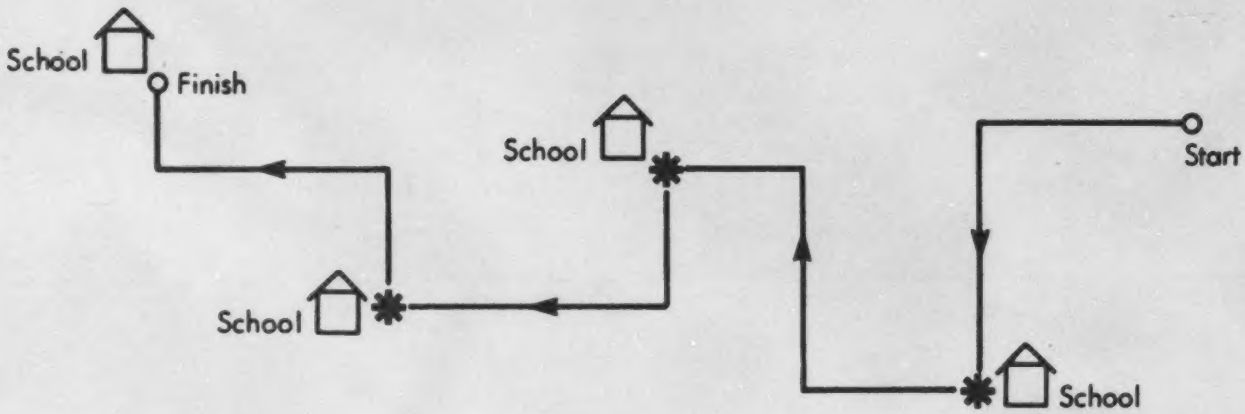
Frequently, it may be uneconomical to route a bus along a road where only one student or a small group of students live at a point part of the way along the road. Or, there may be occasions when for reason of route efficiency the designer may not wish to have a bus travel on a particular road. In these cases a turnaround (Figure C-3) may be incorporated into the route. The bus proceeds along the road to pick up the students, then turns around at a convenient location, retraces its path back to the next crossroad and proceeds on the main part of the route. In this way, the turnaround can also be used as an alternative to feeder routes when road conditions permit. The turnaround should be used only when a safe place is available for the reversing to take place. Turns on busy highways should be avoided. Also, because the bus retraces its path, the turnaround can lead to inefficiencies if used too often on a single route.

C.1.5 Multi-School Routes

The multi-school route layout is used when it is desirable to have students destined for two or more schools to travel on the same bus (Figure C-3). With this type of route layout students are picked up and then dropped off at one of several schools located on the route. Since the bus arrives at the schools in sequence, it is important that the travel time between schools is not too great or else students will be dropped off too early at the first school, or too late at the last. The usefullness of this type of route is therefore primarily dictated by the distances between schools in the area. The multi-school route is particularly



ROUTE INCORPORATING TURNAROUNDS (Morning Run)



MULTI-SCHOOL ROUTE (Morning Run)

DIRECTION OF TRAVEL

PICK-UP / DROP-OFF POINT

Stanley

Figure C-3
OTHER SERVICE CONCEPTS

useful in areas where there are towns, subdivisions or other concentrations of students along the route between schools. In this case, students can be dropped off at the first school, and the bus filled up again before reaching the second, thus increasing the utilization of the vehicle. In basic design, the multi-school route can be either a circular or a direct route type. It does, however, present quite different timing and scheduling problems, particularly in terms of arrival and departure times, for the schools concerned.

C.1.6 Types of Service Provided

In addition to the basic layout of the routes, the designer must also consider the various methods of serving or operating the routes. The approach to serving the routes will have an important effect on both the quality of service provided to the students and the economy of operations. There are three types of route operation:

- single trip service
- multiple trip service
- dual trip service

The single trip service means that a bus is used on each route for only a morning and an afternoon trip. This form of service is common in sparsely settled regions or schools with large attendance areas. The single trip plan requires a maximum number of buses and drivers as each route is covered only once, and each bus serves only one route.

Bus allocations can be improved by using the multiple trip service. With this operation each bus covers one or more different routes in both the morning and the afternoon. Often called the double

or triple run, this approach is well-suited to more densely populated areas where distances between the students and their schools are not great. It is a particularly efficient type of service when large numbers of children live in towns and subdivisions relatively close to school.

As an example a bus may be used to bring students from farther out in the school jurisdiction on its first run and then operate as a shuttle service to a nearby concentration of students on its second or third run. Providing the scheduling can be worked out satisfactorily, this plan for serving the routes can be very economical because it uses fewer buses.

The dual trip service is a variation of the multiple trip service. Under this concept the bus makes two or more trips over the same route. Like the multiple trip, this arrangement is feasible only in areas where students are concentrated over relatively small areas and the distances between students and their schools are short. This approach does, however, have the advantage of transporting more students with one bus than the single trip.

C.2 OTHER DESIGN FACTORS

In addition to the above mentioned techniques the route designer must be aware of factors which impact on how efficient the resultant route design is. These factors include determining bus stop locations, transfer point locations, bus speeds and timing of routes.

The location and spacing of bus stops is very much dependent on the school board's service policies, the density of students in the area, and local road configurations. Maximum distance between stops will be dictated by the board policy on the maximum distance students must walk before boarding a bus. Obviously, the stops cannot be spaced more than twice this distance apart. Where students' homes are located far apart, then it is logical to pick up each student at his residence or laneway. Where students are located in towns, subdivisons or other groupings, a stop can usually be established in a safe place convenient to all.

A few general rules should be observed when locating stops, mainly relating to safety considerations:

- Where a stop is to serve a large number of students, it should be located in a location where the bus can pull off the road and return to the road while moving forward and in clear view of oncoming traffic.

- Stops should be located in such a way that children do not have to cross or walk along a main highway to get to and from the stop. Generally, crossing of roads should be reduced as much as possible.

- Stops on hills with an appreciable grade should be avoided, and if such stops are necessary, they should be served while the bus is travelling downhill.

- Stops on sharp corners and other locations where visibility may be limited for oncoming vehicles should be avoided.

Transfer locations, if required are really a particular category of bus stop, made more important, however, by the usually larger number of students being transfered and the need to be able to park two vehicles at the stop. On certain types of routes, transfers can be arranged to be placed at schools where there is ample room and an awareness of the safety precautions needed. On others where transfers must be made away from schools, it is advisable to try to locate the transfer points in small towns or at corner gas stations where space exists for both buses to pull off the road. Open road transfer points should be avoided.

Following the establishment of a route and location of the stops and transfer points, if required, the time of arrival of the bus at the various points along the route and the school should be determined. This will permit an evaluation of whether or not the proposed route can be operated within the school board's service policies. In order to determine the bus schedule the following information is required:

- average bus travel speeds between stops
- number of pupils boarding and alighting at each stop
- allowances for special conditions.

Average bus speeds between stops will vary primarily with the types of roads travelled and the distance between stops, and to a lesser extent with the size of the bus and the driver. Rather than attempt to make allowances for all these variables, it is common to assume an average speed between stops based on the designer's experience with previous routes and actual clocking of buses in the area. These speeds should normally be based on winter road conditions unless separate schedules are adopted for summer and winter operations.

The number of pupils boarding and alighting at each stop impact on the schedule since the average boarding and alighting time varies somewhat with the actual number of pupils involved. That is the pre-boarding and post-alighting times remain constant at each stop, however the actual time spent boarding and alighting will vary by number of pupils involved. Consequently the total time spent on each stop is not directly proportional to the number of students involved. This time can be easily measured by riding on a few routes and timing the various boarding and alighting sequences.

Allowances for special conditions should be made for such items as; signal light locations, roadway links of known congestion delays, areas where timing problems have been experienced in the past, known train schedules which block railway crossings at designated periods and so on.

APPENDIX D

COMPUTER ASSISTED APPROACHES TO SCHOOL BUS ROUTE PLANNING

Some computer programs have been developed to deal with the school bus routing problem. The principal objective guiding the development of these programs was to develop a system which could reduce the manual work required in route planning while producing routes at least as good as those which could be produced manually by experienced route designers. A summary of the principal efforts in this area follows.

D.1 O.I.S.E. COMPUTERIZED ROUTING SYSTEM

This system, prepared by the Ontario Institute for Studies in Education under National Research Council of Canada funding, was developed in association with officials of the Waterloo County Board of Education. The procedure for route design was based on the Clarke-Wright algorithm and was tested on some routes in Waterloo, although the route designs were not published.

Knowledge of the program's mathematical formulation is not required to use the program. All that is required to operate the automated procedure is the ability to prepare the following required data input:

1. Bus stop locations within the district and a map showing all traversible roads and a coordinate system by which the bus stops and the students can be located;

2. Distances between bus stops converted to time (minutes);

3. The maximum time any student is required to travel on a bus (e.g., 60 minutes/day);

4. The starting school time;

5. The number of buses available and their respective capacities.

Using the above data this computerized bus routing system provides its users with the following output for each designed bus route:

1. The bus capacity;

2. The bus stops visited (in order of pickup);

3. The times of arrival at the bus stops and finally at the school;

4. The number of students on the bus;

5. The direction of the trip from the first pickup to the school;

6. The "student-minutes" for the trip, where "student-minutes" is the sum of the travelling times of every student on the trip. This is obtained by multiplying, for each pickup point or bus stop, the number of students at the point and the time these students will be on the bus.

D.1.1 Reported Benefits of This Program

Adoption of the computer based procedure for designing bus routes does not require a school system to abandon manual procedures for planning such routes. The use of the computer based procedure, even for a limited time, can:

- provide a board with a working outline of routing patterns that may be used as the basis for designing future routes using their regular manual methods;

- considerably reduce the manual effort involved in the annual designing of bus routes for an entire school system.

Another advantage of the automated system is the variety of auxiliary uses to which it can be put. This system can be of assistance in reviewing attendance boundaries, choosing the site locations for new schools, and estimating future student location patterns in order to determine school building and equipment requirements.

As previously mentioned, the program was tested in Waterloo, Ontario. The computer cost of running the program to design routes for one high school and a group of elementary schools (1,265 students) was less than five dollars. Since the system is so inexpensive to use, a board could, from time to time, perform various tests on certain variables under its control. The model allows a school system to assess the effect of alternative policies and practises in pupil transportation and to select to best of these.

D.2 "MISSISSIPPI PROGRAM"

This computer program was developed at the University of Mississippi with the aid of a grant from the U.S. Office of Education.

The original program, written in Symbolic Programming System (SPS), was re-written in Fortran to promote its wider use. Objectives of the new program were to:

- expand and refine the program to increase the speed and decrease the memory requirements;

- present the program with detailed comments.

The revised program is really a "bookkeeping" procedure which reportedly offers school administrators and transportation departments an efficient method of coping with the clerical tasks involved in school bus routing, thus enabling school systems to use more effectively both professional and clerical personnel.

Three types of data are required to use this program as follows:

1. Each stop or pick up point in the school system is assigned a stop number. The location of each stop may be described in terms of street addresses or local landmarks. The school site is also assigned a stop number.

2. A "KIDS Matrix" is constructed. A "KIDS Matrix" is a list of stop numbers and the number and type of students at each stop.

3. A "LMAT-MLINK Matrix" is then set up to simulate the school district.

The first step in the actual planning of the bus routes is to arrange manually a bus route which pases through every point in the school system as though only one bus were available to the system. When this route is used as input data, the program divides the route into several smaller routes using the bus capacities specified in the input data for the program. By varying the order of the buses, if all the buses are not the same capacity, different sets of routes can be prepared. N combinations of these routes are then tried and checked for errors caused by not being able to go from one point to the next in the route, and then all routes which have no errors and a route time less than or equal to the original route time are printed.

The output from the program consists of the following: the route number, the generation number, the route time, the number of students transported, the bus capacity, the student riding time, the school starting time, the

school dismissed time, the school arrival time, the school leaving time, the stops on the routes and their addresses, the arrival time of the bus at each stop in the morning and afternoon, and the number of each type of student at each stop.

This program was tried for a small rural attendance area in Wisconsin and was reported to have produced routes which "compared favourably with routes prepared manually, and in some instances ... were better". The program was available in FORTRAN IV.

D.3 IBM VSP

This program is a standard vehicle scheduling package primarily developed to optimize routes for a fleet of vehicles delivering goods to customers from a central depot. With this program, two different methods of calculation can be used:

- the true-distance method, which utilizes distance in its computations;
- the grid method which uses speed on a grid type network to achieve the same results.

As yet this program is available only in-house at IBM in Alberta. However, published reports give no promise of greatly improved routes over those developed manually, although design times was reported to be reduced. Several versions of this program are available.

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County of Paintearth, Castor, Alberta (No. 18)
County of Lacombe, Lacombe, Alberta (No. 14)
County of Barrhead (No. 11)
Fairview School Division (No. 50)
Drumheller Valley School Division (No. 62)
Red Deer Public School District (No. 104)
Edmonton Public Schools
Spruce Grove Catholic School District
Lethbridge Catholic Separate School District (No. 9)
County of Strathcona (No. 20)
Fort Saskatchewan R.C.S.S.D. (No. 104)
County of Camrose (No. 22)
Sturgeon Heights School Division (No. 24)
Bonnyville School Division (No. 46)
County of Wetaskiwin (No. 10)
Medicine Hat School District (No. 76)
Provost Roman Catholic S.S. District (No. 65)
Crowsnest Pass (No. 63)
Lethbridge School District (No. 51)
County of Lethbridge (No. 26)
Pincher Creek School Division (No. 29)
County of Newell (No. 4)
Brooks School District (No. 2092)
County of Lamont (No. 30)
Berry Creek School Division (No. 1)
Lac La Biche School Division (No. 51)
Taber School Division (No. 6)
Rocky View School Division (No. 41)

Rocky Mountain School Division (No. 15)
Redcliff School District (No. 2283)
Camrose Separate School District (No. 60)
County of Stettler (No. 6)
Yellowhead School Division (No. 12)
Bow Corridor Regional School District (No. 5)
Swan Hills School District (No. 5109)
McLennan R.C. Separate School (No. 30)
St. Paul School District (No. 2228)
Jasper School District (No. 3063)
Westlock R.C. Separate S.C. (No. 110)
Picture Butte R.C.S.S. (No. 79)
Pincher Creek, St. Michael R.C.S.S.D. (No. 18)
Provost School Division (No. 33)
Medley School District (No. 29)
Waterton Park School District (No. 4233)
County of Parkland (No. 31)
Grand Prairie School District (No. 2357)
County of Vermilion River (No. 24)
Willow Creek, School Division (No. 28)
County of Thorhild (No. 7)
Grand Prairie R.C.S.S.D. (No. 28)
High Prairie School Division (No. 48)